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Apollo 11: 50 years on
What was its impact?

6 lunar landings
explored in detail

#170 JULY 2019

Sky at Night

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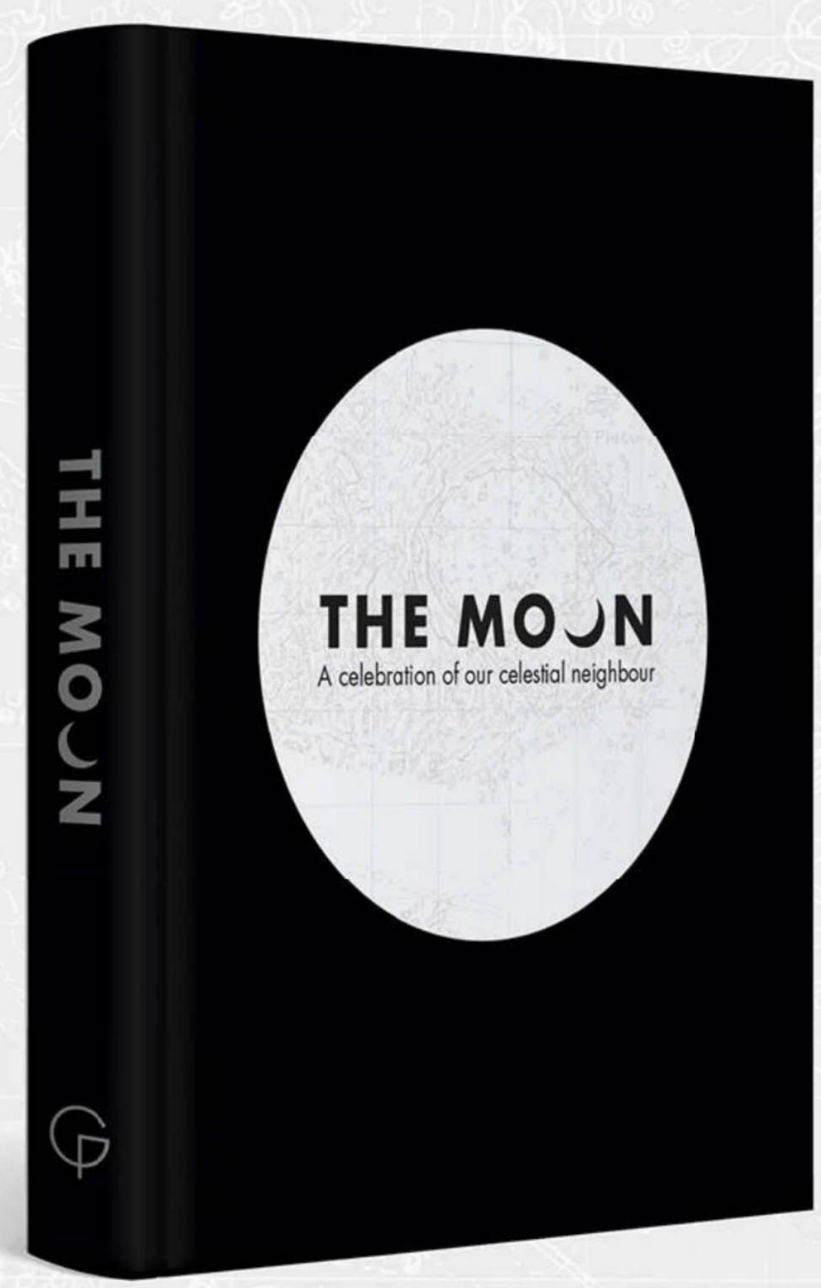
COSMIC COLLISION
What would a neutron star crash look like?

Marking the 50th anniversary of Neil Armstrong's 'small step' this beautiful book explores people's fascination with our only natural satellite.



- Published to coincide with *The Moon* exhibition at Royal Museums Greenwich
- Contemporary essays and fascinating images are presented in a sleek black design
- Edited by the exhibition's curators, Melanie Vandenbrouck, Megan Barford, Louise Devoy and Richard Dunn
- Contributions from cultural historians, a scientist, a poet and a space law expert, among others, explore how art and science are inextricably linked in our study of the Moon


The Moon through the Eyes of the Apollo Astronauts

Jennifer Levasseur

Former astronaut and Apollo 17 Commander Gene Cernan (1934-2017) said of the iconic image of Earth his crew took during the mission, the last to touch the Moon: '[W]e've only seen ourselves through the paintings of artists, words of poets or through the minds of philosophers. Now we've been out there, we can see ourselves.'1 Cernan, the last person to walk on the Moon, made clear the profound impact of astronaut photography on our conceptions of both Earth and humanity. He was hardly alone among astronauts, many of whom communicated a sense of obligation and honour in providing people around the world with these portals into the spaceflight experience. The Apollo programme yielded nearly 20,000 still images, which serve as a valuable visual and scientific record of the programme, in addition to the hundreds of hours of movie footage and television broadcasts. For those who took the photographs, they are images infused with memories and personal identity. It is through astronaut eyes that we come to see ourselves anew: from an orbital perspective, as creatures caught between Moon and Earth, and as explorers of what Apollo 11 lunar module Pilot Buzz Aldrin (born 1930) called 'magnificent desolation'.

From the iconic to the mundane, these widely reproduced photographs constitute the primary source of the collective memory of early human spaceflight, especially because they evoke familiar visual themes present throughout the history of exploration photography. Photographers and expedition leaders, guided by intentions of economic and political expansion by colonial powers in the late nineteenth and early twentieth centuries, provided visual evidence that fit rhetorical need. The byproduct of this process was thematic visual categories, often repeated through exploration of other environments on Earth and in space. With such heroic figures providing visual documentation of their experiences, the images were universally admired as symbols of great achievement during challenging times, when belief in American exceptionalism was tested at home and abroad. Still photographs, as opposed to television or movies, were accessible technical records as well as rhetorical vehicles: documents for scientists and engineers involved in making the Moon landings a reality, and symbols within the context of the history of exploration photography and the Cold War.

Apollo photographs, with such similar visual character to those of terrestrial exploration, tell viewers little of how astronauts actually captured images. Astronauts were, in every sense of the word, amateurs in the art and craft of photography, trained as they were for so many other activities never before attempted. Men who would explore the Moon – women were not selected as astronauts until 1978 – typically arrived at NASA as trained pilots, engineers, and later, scientists. Few had more than passing experience with cameras as family photographers. NASA provided professional photographers to train astronauts in composition, lighting and perspective. Astronauts learned the technical and scientific capabilities of photography, but were also encouraged to capture targets of opportunity, those awe-inspiring sights that might catch the eye of any tourist. Engineers prepared astronauts in advance with systematic plans for the photographic work while also ensuring the plans accounted for the needs of multiple audiences – NASA managers, engineers, scientists, government administrators, NASA public affairs, the media, corporations, and of course, the public.

NASA developed detailed scripts (checklists) for crews to follow throughout their missions, with photographic work spelled out and time allotted for spontaneous crew-selected images. Once images arrived back on Earth, NASA public affairs staff collaborated with the astronauts to decide which images to release publicly, and how to interpret them with accompanying text. This process, from planning, to execution, to circulation, mirrors the rigour with which NASA performed many of its public service components, making it a routine, but one that aided our understanding of one of the most stunning human achievements to date.

Apollo photography was shaped as much by the needs of Cold War politics as it was by the cultural shift of the Sixties that increased public consumption of visual media. Before, during and after the Apollo missions of the

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The so-called Blue Marble image taken by the Apollo 17 crew just five hours into their mission to the Moon, December 1972

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Space Cadets: Toys and Material Culture from *Sputnik 1* to Apollo 11

William Hanson

The Space Race was one of the more intriguing proxies of the Cold War. Space travel moved from the realm of science fiction to that of science fact, and children's interests and material culture followed it. The breakneck progress made between the launch of *Sputnik 1* in 1957 and the first Moon landing in 1969 unfolded on television screens around the globe. Amazing first-time images of the sublime beauty of outer space, gleaming astronauts, and the long-held intrigue of the lunar surface appeared alongside a golden age of children's television. In parallel, the technological leaps that enabled the Space Race mirrored leaps forward in toy manufacturing technologies. During this period, space permeated all aspects of children's lives, from pocket money storage to bedspreads, toys to comic books. The combination of real and fictional TV programming and great toys captivated young imaginations worldwide.

Generally, children's material culture relating to the Moon and to space endorsed a spirit of optimism and faith in technological progress that permeated Western culture during the Fifties and Sixties. The style of toys produced around that period reflected the same ethos. This stemmed from a growing vocabulary of visual culture that was introduced through the Space Race. It was also a result of the sense of excitement caused by persistent advances, and from the fierce competition between the American and Soviet superpowers. Stated simply, at the start of the Space Race in the mid-Fifties, toys generally had a more fantastical, 'sci-fi' appearance. Once the Space Race took off, these toys gradually became more realistic, taking cues from actual missions, technologies and political ambitions in space.

After the Second World War, the Allies supported industrial recovery in Germany and Japan. Among the industries revived in both nations was toy-making, at which Germany had traditionally excelled. However, it was Japan that reaped the benefits of post-war investment, becoming the first Far Eastern centre for toy manufacturing. The pre-eminence of Japanese toys was established by the mid-Fifties, a result of direct financial support from the US, and preferential access to the American toy market. Crucially, Japanese manufacturers were able to perfect small battery-powered motors, which gave Japanese toys a superior range of movements and novelty features. Developments in lithographic printing processes allowed a finer level of detail to be applied to the surfaces of metal toys. Improved plastics technologies, developed during the Second World War, democratised access to toys by making them cheaper to make and buy. Plastics allowed an unprecedented level of detail, whilst also being modern, sanitary and in many ways 'space age'. These factors, along with the reduced costs of manufacturing, helped plastics take off as the most common materials for making toys.

When *Sputnik 1* was sent to orbit in October 1957, placing a human being in space, let alone sending one to the Moon, was still some years off. However, other milestones were exploited by manufacturers and the popularity of *Sputnik* proved to be a gift. A number of tin-plate 'manmade satellite' toys appeared that vaguely resembled the spherical form of *Sputnik*, but that were designed to be a good deal more exciting than the real thing. Some of these toys 'carried' animal crews of dogs, monkeys or bears, inspired by real-life counterparts such as Laika the Soviet dog, the first animal in space. These toys were brimming with character, and were an early indication of a change in the style of space toys, as they were explicitly influenced by real breakthroughs.

Spaceflight brought with it a new visual language of towering rockets, solar panels, and spacesuits in bright orange and shiny silver. These were quickly assimilated into toy design. At the start of the Space Race, there were numerous imaginative concepts for what spacecraft could be. Many were divorced from the reality of rocketry, instead resembling science fiction-style flying saucers. As the years passed and spaceflight developed, and human beings came ever closer to visiting the Moon, children came to expect greater levels of realism. The spacecraft and equipment used in real missions, and in activities such as spacewalking, began to be actively copied to make toys, collectibles,

Alan Alcide Satellite. Yonezawa Toys, Japan, late 1950s

Capsule-7 mechanical toy, c.1963

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Hardback £20.00

ISBN 9780008282462

Official book for *The Moon* exhibition at Royal Museums Greenwich, from 19 July 2019–5 January 2020

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Welcome

The Moon landings have shaped our view of the modern world

We're excited to be nearing the 50th anniversary of Apollo 11 in July, and to celebrate the first human steps on another world. The story of what is arguably humankind's greatest technological achievement is an epic tale, with interweaving aspects so wide in their reach that this month we're looking at select parts.

We begin on page 30 where Nick Spall examines the impact the successful Moon landing had on society, and where we can still see the Apollo programme's influence to this day. Of course, Apollo 11 wasn't the only mission to reach the lunar surface, it was the first of six. On page 37, Sue Nelson looks at each of the landing sites and what each of the two-man crews achieved on their extravehicular activities.

The mastermind behind the Moon landings, Wernher von Braun, intended the Apollo programme to be the foundation for crewed missions to Mars and, around the time that Neil Armstrong took his first step off the Eagle, was proposing a strategy for long-range travel to the Red Planet. On page 60, David Baker assesses von Braun's plans and examines the parts that were and weren't to see the light of day.

Also this issue, from page 43 Pete Lawrence and Stephen Tonkin are your guides to the best observing this month, which rather serendipitously includes a partial lunar eclipse on the night of 16 July, and on page 66 Ralf Vandebergh recounts the fascinating tale of how he tracked and imaged a forgotten piece space junk, which turned out to be a lost Russian probe destined for Venus.

Enjoy the issue. We'll have more to celebrate of Apollo 11's 50th anniversary next month!

Chris Bramley, Editor

PS Our next issue goes on sale Thursday 18 July.

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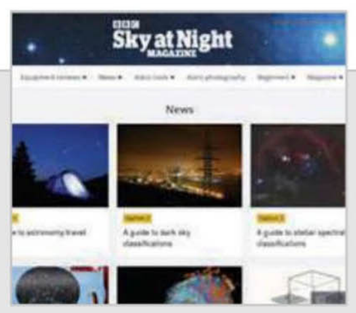
Sky at Night – lots of ways to enjoy the night sky...

Television
Find out what *The Sky at Night* team will be exploring in this month's episode on page 19



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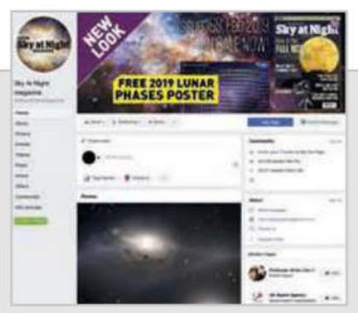

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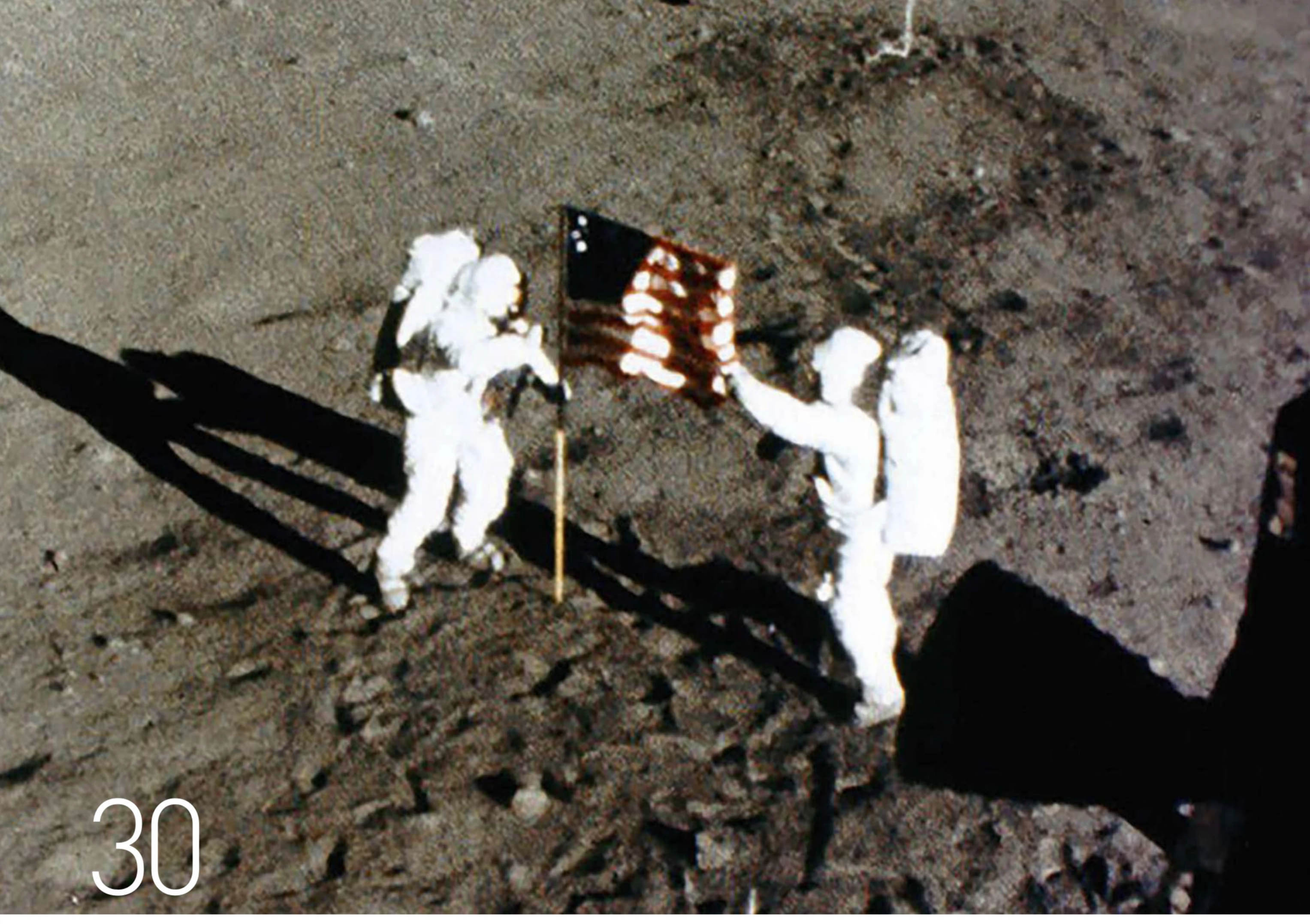

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© = on the cover

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16-PAGE CENTRE PULLOUT

The Sky Guide

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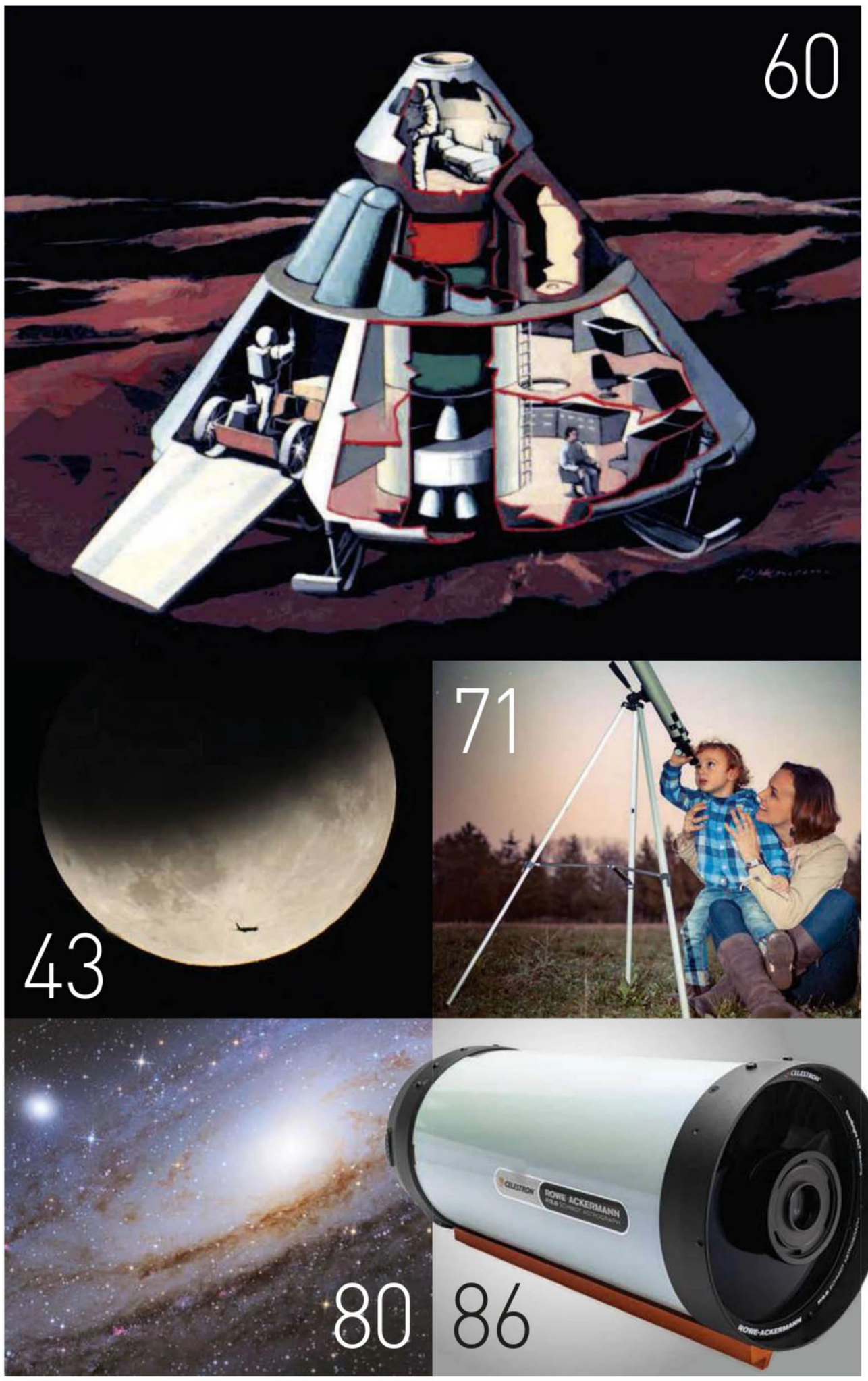
New to astronomy?

To get started, check out our guides and glossary at
www.skyatnightmagazine.com/astronomy-for-beginners



This month's contributors

Jane Green

Astronomy writer and presenter

Jane tells us everything we need to know about July's total eclipse over the Andes. See page 74

Sue Nelson

Space journalist

Sue shows us how to spot the six Apollo lunar sites... and what was left behind. See page 37

Ruth Perkins

Science STEM communicator

There's no age limit on stargazing – Ruth shows us how to enthuse the next generation. See page 71

Nick Spall

Freelance space writer

From JFK to environmental awareness, Nick looks at Apollo's wider cultural context. Turn to page 30

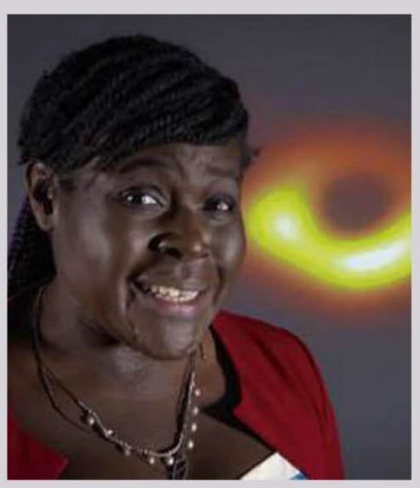
Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/djds6m3/** to access this month's Bonus Content.

July highlights

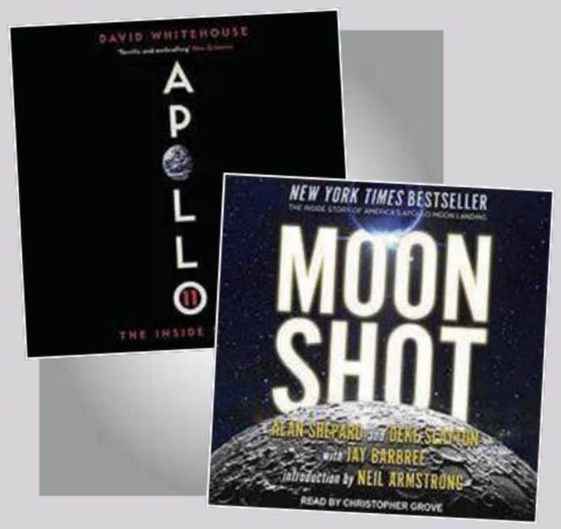
The incredible shrinking Moon

Seismometers placed on the Moon by Apollo astronauts reveal it is shrinking, while ongoing moonquakes show the body is tectonically active. This month we speak to Dr Thomas Watters, author of a study investigating what's going on beneath the surface of our satellite.



The Sky at Night: Imaging a black hole

The team reports live as scientists announce they have captured an image of a supermassive black hole for the first time.



Audiobook previews: An Apollo 11 special

Download this month's audiobook excerpts, looking at the history and legacy of the Apollo 11 moonlanding.

Hotshots gallery, extra EQMOD files, binocular tour, observing forms, deep-sky tour chart, desktop wallpapers...**and much more**

PLUS: Every month

The virtual planetarium

July's night-sky highlights with Paul Abel and Pete Lawrence

EYE ON THE SKY

Astronomy from 37,000 feet

A cargo pilot with a unique view of the cosmos, astrophotographer **Christiaan van Heijst** captures incredible scenes from his Boeing 747

9 AUGUST 2015, EQUIPMENT: NIKON D800 DSLR,10.5MM F/2.8 FISHEYE LENS, EXPOSURE: ISO 2500, 4 SECS

CHRISTIAAN VAN HEIJST

We cruise through the north Canadian night, heading to a heavenly arch of aurora. My colleague is doing her fuel calculations on the flight plan, seemingly oblivious to the magnificent views outside. This is a shot that shows the dramatic beauty of night flights and at the same time the human touch of our residence in the sky: the cockpit of the Boeing 747. These night scenes are challenging to capture from a photographic point of view, but ever since my first flights as a pilot I felt this inner drive to document and capture them as they unfold before me. Such scenes only present themselves once, and no two are the same. These images illustrate the wonder of flight and the cosmos, in an environment that has only quite recently become accessible to humans.

Christiaan van Heijst is a 747 cargo pilot and fine art photographer. See more of his pictures in his debut book *Cargopilot*.

▽ Blue curvature

26 JULY 2018, EQUIPMENT: NIKON D850 DSLR, 14–24MM F/2.8 LENS, EXPOSURE: ISO 1250, 2 SECS

Flying over the mid-Atlantic Ocean, the Moon behind us is illuminating the clouds below, causing the atmosphere to glow dimly. Using a wide-angle objective lens, I captured the curvature of the Earth. For this photo, I placed the camera right up to the windscreen to keep it secure and stable during the long exposure.

▽ Deepspace glow

27 FEBRUARY 2015, EQUIPMENT: NIKON D800 DSLR, 10.5MM F/2.8 FISHEYE LENS, EXPOSURE: ISO 5000, 20 SECS

Heading due east, I noticed how the bright Milky Way was positioned over the horizon, making a nice composition with the upcoming sunrise and the zodiacal light. Being fortunate with the lack of turbulence, I was able to place my camera against the windshield to take this 20-second exposure.

More **ONLINE**
See these and more of Christiaan's stunning images

ALL PICTURES: CHRISTIAAN VAN HEIJST

△ Glowing ribbon

9 AUGUST 2015, EQUIPMENT: NIKON D800 DSLR, 10.5MM F/2.8 FISHEYE LENS, EXPOSURE: ISO 1250, 13 SECS

A striking combination of dancing, multi-coloured aurora, a faint Moon, sunrise and the stars above. The biggest challenge with these kind of shots is to keep the camera as stable as possible, because with even the slightest hint of turbulence or trembling the shots can be ruined. Another challenge is to avoid the reflection of cockpit lights in the window.

▽ First light

23 SEPTEMBER 2013, EQUIPMENT: NIKON D800 DSLR, 10.5MM F/2.8 FISHEYE LENS, EXPOSURE: ISO 400, 30 SECS

A long exposure capturing the zodiacal light over the north Atlantic. The clouds race along below and the colours of the sunrise match the fiery trail of a meteor. These events can never be planned, but if I take enough long exposures in a row, scenes like this are more likely.

Image courtesy of Joe Canzoneri

Perfect for the entry- level astronomer, the Atik Infinity is the first Atik CCD camera dedicated to video astronomy. It is supplied with our new, intuitive, in-house software dedicated to video astronomy, and is well suited to a broad range of telescopes, bringing the wonders of deep-sky imaging to your screen in just seconds.

Atik Infinity
Entry level

CCD TECHNOLOGY
IMAGING WITHOUT COMPROMISE

Atik 460EX
Mid range

Image courtesy of George Chatzifrantzis

The Atik 460EX is renowned for its perfect balance of sensitivity and resolution. It utilises a Sony ICX694, which is the sensor of choice for astronomers looking for the highest-quality data. Its efficiency and generous sky coverage make the 460EX one of the most versatile astrophotography cameras around, ideal for a large range of telescopes.

Atik 16200
Large Format

Image courtesy of Sven Junge

The Atik 16200 boasts a sensor specifically designed for astronomy and having a generous 35mm diagonal. The 16million, 6µm pixel sensor can be freely binned so offers a huge amount of flexibility for both wide field and long focal length imaging. Argon purging, deep cooling and a mechanical shutter make this a camera for professionals and amateurs alike. The Atik 16200 is the camera capable of taking your imaging to the next level.

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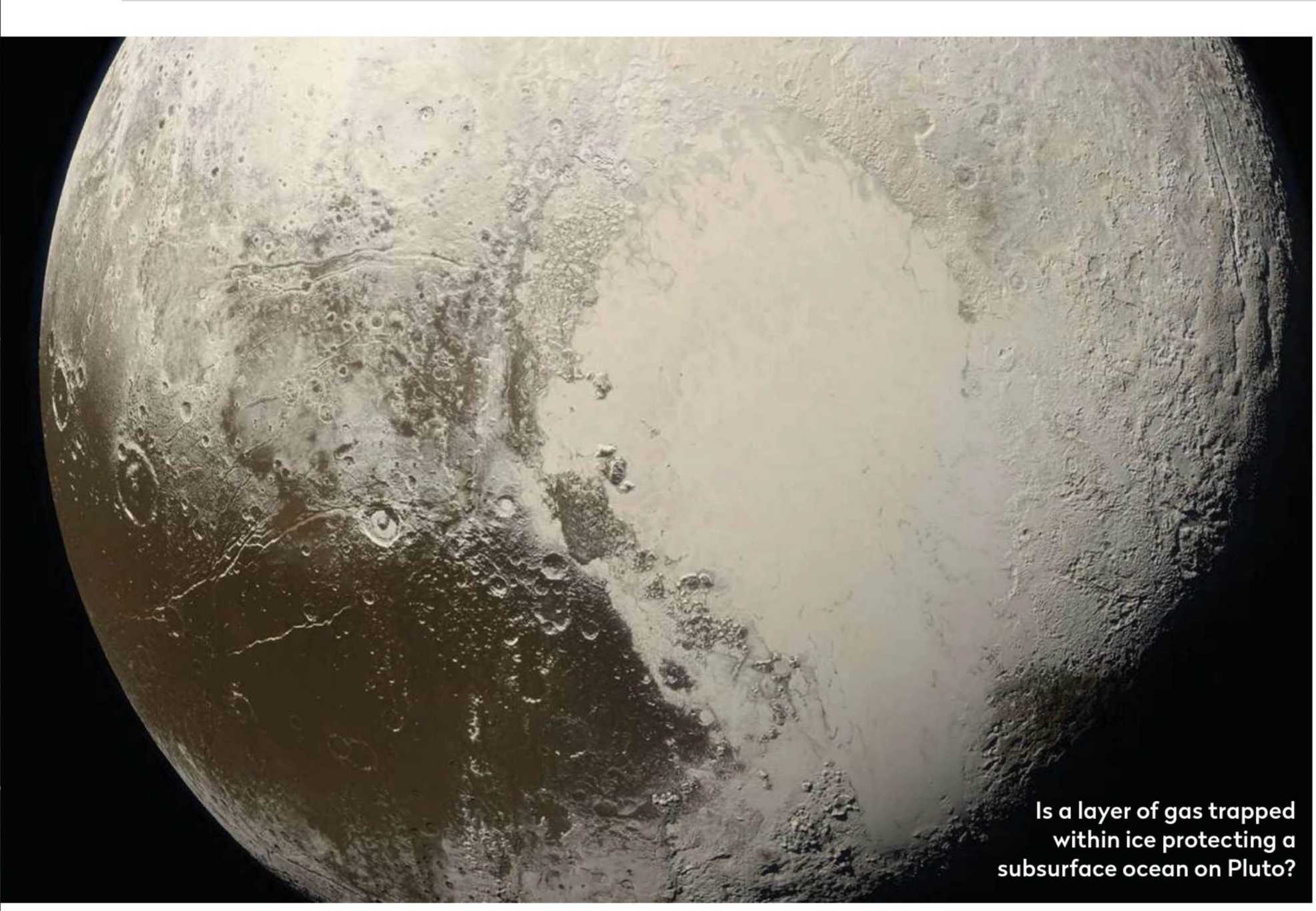


Is a layer of gas trapped within ice protecting a subsurface ocean on Pluto?

NASA/JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY/ SOUTHWEST RESEARCH INSTITUTE/ALEX PARKER

Warming Pluto's icy heart

Exotic ice could be keeping the dwarf planet from freezing solid

A layer of gas-infused ice could be preventing Pluto's interior from freezing over, allowing it to host a sub-surface ocean, according to a new study.

When NASA's New Horizons probe flew past Pluto in 2015, a heart-shaped region near the world's equator captured the public's imagination. But it's the left-hand lobe of this area, Sputnik Planitia, which is drawing the interest of geologists, as it appears to be a giant basin.

"We do not expect big basins near the equator," says Shunichi Kamata from Hokkaido University, who led the research. "If you look at Mars, what you find near the equator are not basins but huge volcanoes."

When a basin is on the equator, the lopsided mass should make the dwarf planet wobble as it spins. As Pluto isn't wobbling, it suggests there's something under the surface of Sputnik Planitia making up the mass. A dense water ocean has been proposed.

However, Pluto should have frozen solid billions of years ago, meaning something is keeping the world warm. Kamata's team wondered whether a layer of clathrates – ice where the water molecules act like a cage, trapping gas – could be insulating the dwarf planet.

To test the theory, the group simulated how Pluto would cool over its 4.5-billion-year lifespan. They discovered that when a clathrate layer was present, the ocean barely froze at all.

"We've found a new, generic mechanism to maintain a subsurface ocean for a long time," says Kamata.

It could be possible that similar layers are keeping icy moons – such as Ganymede and Titan, both of which are thought to have liquid oceans under the surface – from freezing solid too.

http://pluto.jhuapl.edu/

Comment

by Chris Lintott

If our Universe is teeming with life, what does a typical habitat look like? It seems to be a rocky planet, perhaps with oceans, neither too near or too far from its parent star.

If that's your answer, then you're guilty of Earthly parochialism. Results like these make it clear that the Universe likes making icy worlds with oceans inside. Look at our Solar System. Jupiter's moons Europa and Ganymede, Saturn's Enceladus, and now Pluto follow this pattern compared to one and a half habitable rocky worlds – and that's generous to Mars!

If life in such oceans is common its denizens will outnumber us. If any are intelligent, what a life they might have – unaware that above the ice a whole Universe is watching.

Chris Lintott co-presents *The Sky at Night*

A study of molecular clouds in spiral galaxy NGC 300 sheds new light on the growth of stars

ESO, WILL GATER, NASA/ESA/H. WEAVER AND E. SMITH (STSCI) AND R. EVANS (NASA'S JET PROPULSION LABORATORY), MICHAELA PINK

Do stars destroy their nurseries?

Only a small fraction of a molecular clouds' gas is converted into growing stars

New stars rip apart the molecular clouds that created them, a recent set of observations has found. The discovery has helped astronomers decide between two rival theories of how stars grow.

Astronomers had previously thought that these molecular clouds could last for a long time, slowly converting their mass into stars. If this was the case, they expected to find gas and stars in the same place. However, there was also a second theory that stars form rapidly, and their intense radiation heated up the gas, pushing it away. In that case, the stars and gas would appear in different places.

To test which theory was right, the team observed NGC 300, a spiral galaxy six million lightyears away. The team measured the positions of its gas clouds by mapping out the carbon monoxide in the galaxy. The gas is commonly found in molecular clouds and is relatively easy to spot from Earth. To trace the new stars, they observed ionised hydrogen – a superheated form of the gas which usually surrounds hot, young stars.

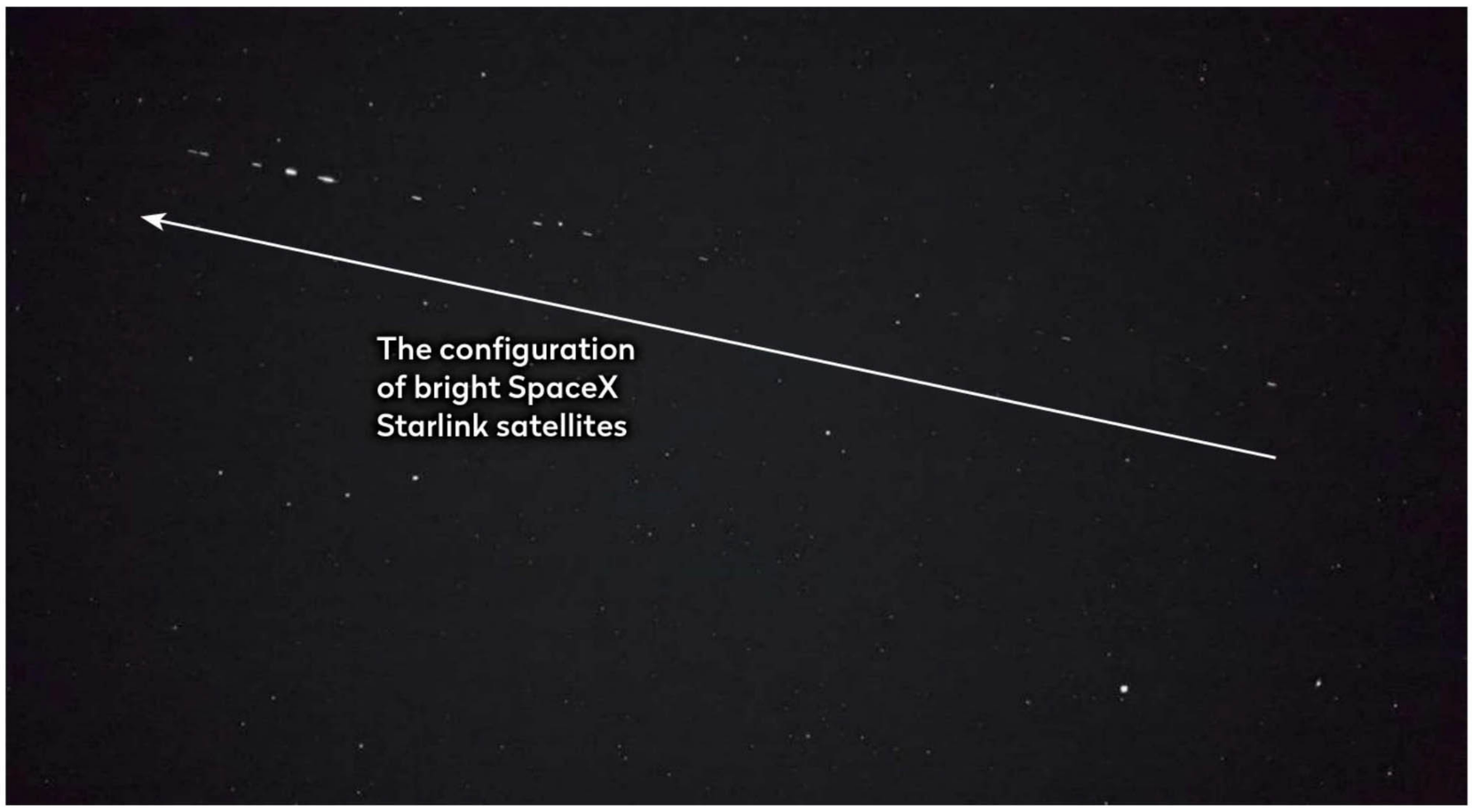
When the two measurements were compared the answer was clear – the clouds and stars were rarely in the same place. It seems the stars form so quickly that only a small portion of the cloud has a chance to be converted into stars before the gas is thrown out.

"Star formation proceeds very rapidly and highly inefficiently," says Diederik Kruijssen from the University of Heidelberg, who led the study. "Molecular clouds in NGC 300 live for about 10 million years and take only about 1.5 million years to be destroyed, well before the most massive stars have reached the end of their lives and explode as supernovae."

The two stages are so distinct that they can be clearly seen as two separate phases of the stellar life cycle.

"The intense radiation from young stars disperses their parent molecular cloud by heating it and dispersing it in the form of hot interstellar gas bubbles. This way, only two to three percent of the mass in molecular clouds is actually converted into stars," says Mélanie Chevance, also from the University of Heidelberg.

https://www.uni-heidelberg.de/



▲ The Starlink satellites appear in a distinct line across the night sky, but will spread out over time

SpaceX launches 60 new satellites

The initiative has caused concern in the astronomical community

Spaceflight company SpaceX has launched the first 60 of a proposed 12,000 mini satellites as part of its Starlink project, sparking controversy among astronomers, both amateur and professional.

The issue is that the satellites are highly reflective, and visible to the naked eye shortly after launch. As they increase altitude and adjust their solar panels, their brightness changes, but they are likely to remain luminous enough to interfere with telescope observations.

SpaceX CEO, Elon Musk, announced via Twitter that the Starlink team would work to ensure the satellite's brightness is kept to a minimum and does not interfere with scientific observations.

Once Starlink is fully deployed, the satellites will provide high-speed internet to remote areas. Each satellite is expected to last five years, at which point it will deorbit itself to prevent space junk accumulating.

https://www.spacex.com

Uncovering Jupiter-like exoplanets

A new technique for finding large exoplanets could help test the theory that gas giants around other stars act as meteor magnets. It's thought that Jupiter and Saturn act as cosmic guardians within our own Solar System by pulling asteroids and comets away from colliding with the inner planets, which could potentially cause a mass extinction.

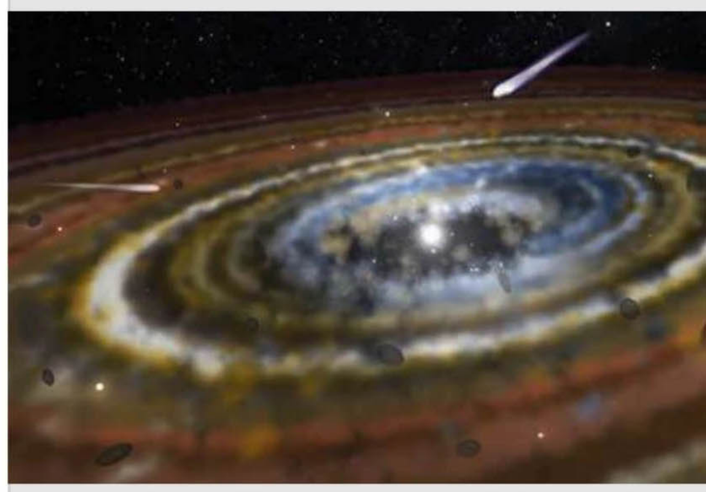
"Understanding how many other stars have planets like Jupiter could be very important for learning about the habitability of planets in those systems," says Stephen Kane from University of California, Riverside, who lead the study.

▲ Jupiter attracts comets, like Shoemaker-Levy 9 in 1994

However, astronomers currently have difficulty understanding what role Jupiter-like exoplanets play in other planetary systems as they struggle to find them. Most exoplanet search methods require watching a planet for a whole orbit, meaning it would take 12 years to find Jupiter. Instead, the team developed a new method involving direct imaging of the planet, a technique which has only recently become technologically possible. A trial study of 20 stars proved successful, finding three planets.

https://news.ucr.edu

NEWS IN BRIEF



First exocomets found

Not one, but three comets have been found around distant star Beta Pictoris, the first time such objects have been seen outside the Solar System. The 'exocomets' were detected by the TESS exoplanet hunting satellite. It looks for the dip in a star's light when a planet transits in front of it, but is sensitive enough to detect comets.

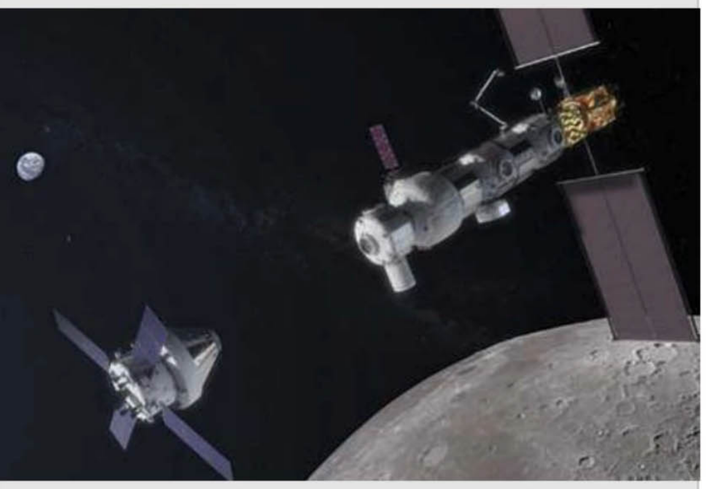
Mars still has polar cap

An ancient water ice cap could be lying a mile below Mars's northern pole. It was thought that the planet had lost its ancient ice layer, but recent results from NASA's Mars Reconnaissance Orbiter show that ice is still there. Geologists hope to use the ice to study how the planet's climate has changed over billions of years.

UK funds space launchers

Airports wanting to develop horizontal space launch capabilities can now apply for a grant from the UK Space Agency's new £2m development fund. The money can be used to build the infrastructure needed for spaceplanes to use a runway. The move is part of long-term goals for the UK to capture a larger share of the worldwide space economy.

NEWS IN BRIEF



Moon station progresses

NASA announced in May that Maxar Technologies, a space technology company, will build the first element of the Lunar Gateway – a space station that will allow the agency to commence long term operations at the Moon. The announcement marks a critical step towards making long-discussed plans of returning humankind to the Moon a reality.

Moon brought Earth water

Water could have been brought to Earth by the collision which created the Moon. A study has found that Theia – the Mars-sized planetoid which collided with the proto-Earth to create the Moon – probably came from the outer Solar System. Unlike objects which formed in the hot region close to the Sun, like Earth, the planetary bodies created further out tended to be rich in water.

New planets, old data

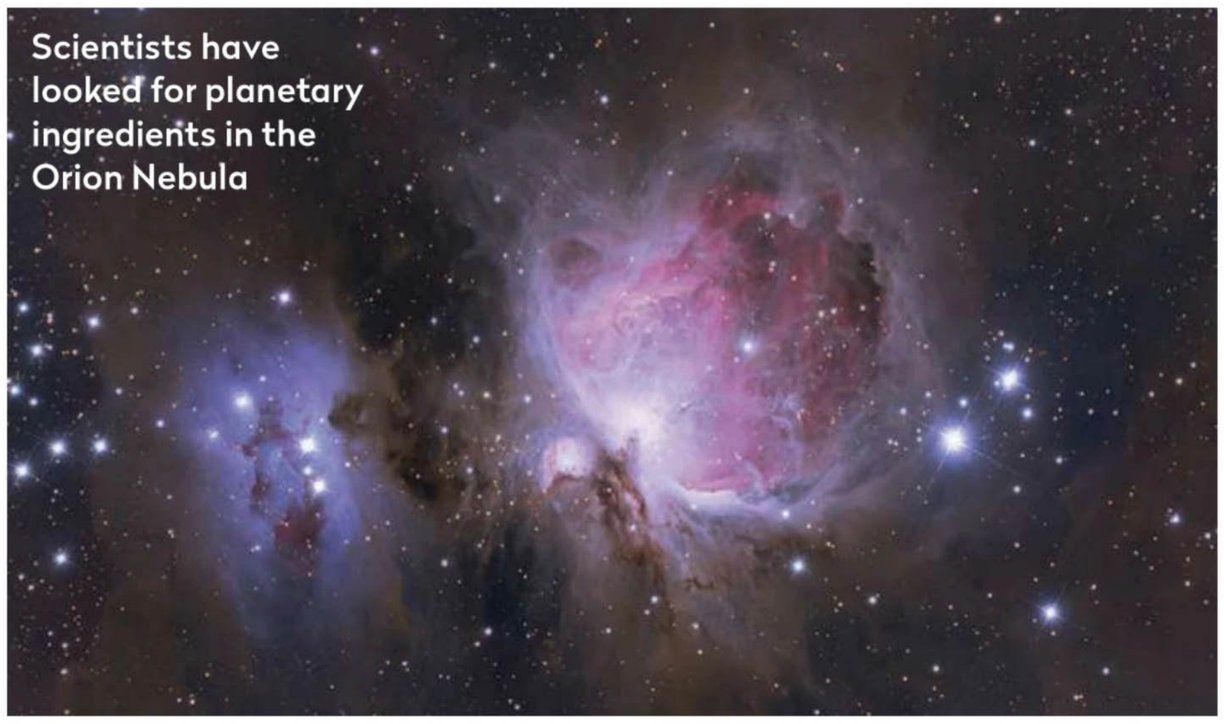
18 Earth-sized planets have been uncovered after a recent reanalysis of data from NASA's exoplanet hunting satellite, the Kepler Space Telescope. The team found more than 100 new planets, including the smallest exoplanet discovered by Kepler so far.

NASA, DZIKA MROWKA/ISTOCK/GETTY IMAGES, CNSA/CLEP

BULLETIN

Planetary building blocks formed quickly

Elements found in early rocks reveal clues about young stars



Scientists have looked for planetary ingredients in the Orion Nebula

The raw material needed to make planets rapidly condenses around young stars, according to a new study of meteorites.

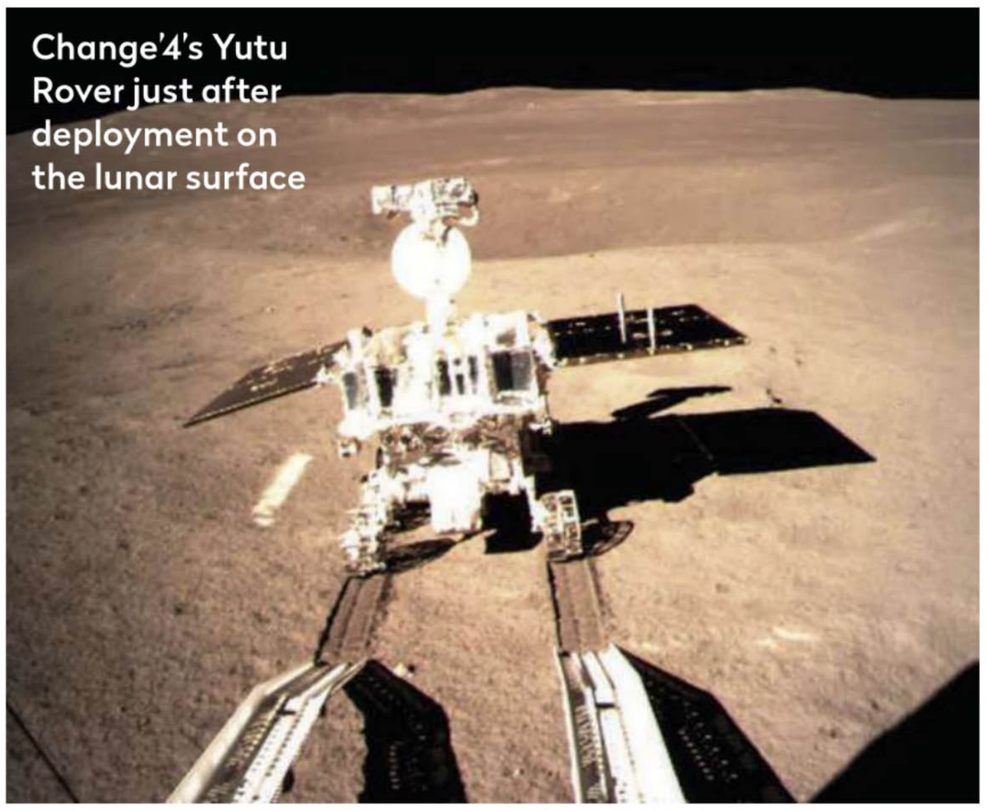
By studying the space rocks, geologists have been able to track down the earliest solid material formed within our Solar System, known as calcium and aluminium-rich inclusions (CAIs). These appear as white speckles found in meteorites and contain aluminium compounds, which solidified out of the cloud of hot gas left when the infant Sun formed 4.5 billion years ago. However, scientists have little idea of how that happened. To find out, astronomers looked at aluminium monoxide (AlO) around a young star in the Orion Nebula.

"The distribution of AlO is limited to the hot region of the outflow from the disc. This implies that AlO rapidly condenses as solid grains – similar to CAIs in our Solar System," says Shogo Tachibana from the University of Tokyo, who led the study.
https://www.u-tokyo.ac.jp/en

Far side of the Moon's origins in question

Astronomers are still in the dark over the Moon's far side, after the latest results from the Chang'e 4 lunar probe only deepened the region's mysteries.

Chang'e 4 landed in the South Pole-Aitken (SPA) basin, a crater spanning 2,500km, on 3 January 2019. It's thought the basin was a magma ocean during the Moon's infancy. As the molten rock cooled, the heavier elements sank, so that when the basin solidified it formed a volcanic crust over a mantle of denser minerals, such as olivine.



Change'4's Yutu Rover just after deployment on the lunar surface

"Understanding the composition of the lunar mantle is critical for testing whether a magma ocean ever existed," says Li Chunlai, from the National Astronomical Observatories of Chinese Academy of Sciences, who led the study.

Over time meteorite impacts have exposed the mantle, meaning Chang'e 4's Yutu2 rover can investigate the material. So far, though, the rover team has only found traces of olivine, raising doubts over how the basin formed.

"The absence of abundant olivine in the SPA interior remains a conundrum," says Li Chunlai.
http://english.cas.cn

OPENS UP NEW HORIZONS – Omegon ProNewton plus EQ-500 X Drive for a superior introduction to astronomy

Photo: Cristian Fattinnanzi

Omegon's pro Newtonian telescopes are better equipped than the average beginner's telescope. You can select between three different OTA.

The EQ-500 X Drive is a tracking mount for small- to medium-sized telescopes. For relaxed visual observing without the irritation of manual tracking – and for successful astronomy photos.

Excellent workmanship

Not plastic, but metal, and workmanship that is a cut above the usual beginner's telescope - for a first class introduction to astronomy.

94% reflectance coating

With a reflectance of 94%, the BK7 main mirror provides you with extra-bright images and great contrast - discover objects that would never be visible with a lesser telescope.

Precision focusing thanks to Crayford focuser

Insert any 2" or 1.25" eyepiece and observe using the magnification of your choice. The Crayford focuser employs ball-bearings to let it move smoothly and precisely, so you can find the exact point of focus even at high magnifications. You can find the exact focus point even with a camera - for your dream photos.

Which OTA is it to be?

A 150mm f/5: a compact OTA for ambitious beginners and astrophotographers, a 150mm f/6: an all-rounder with a longer focal length, or a 200mm f/5: a classic for faint objects.

Powerful tracking mount

The EQ-500 X Drive has stepper motors on both axes to automatically track astronomical objects.

High stability

Whether refractor or Newtonian - this mount can carry small to medium telescopes up to a maximum weight of 10kg. Along with the mount, a steel tripod ensures stability.

Portable transport

No matter where your journey takes you: the ideal companion to any place in the world – also thanks to easy disassembly.

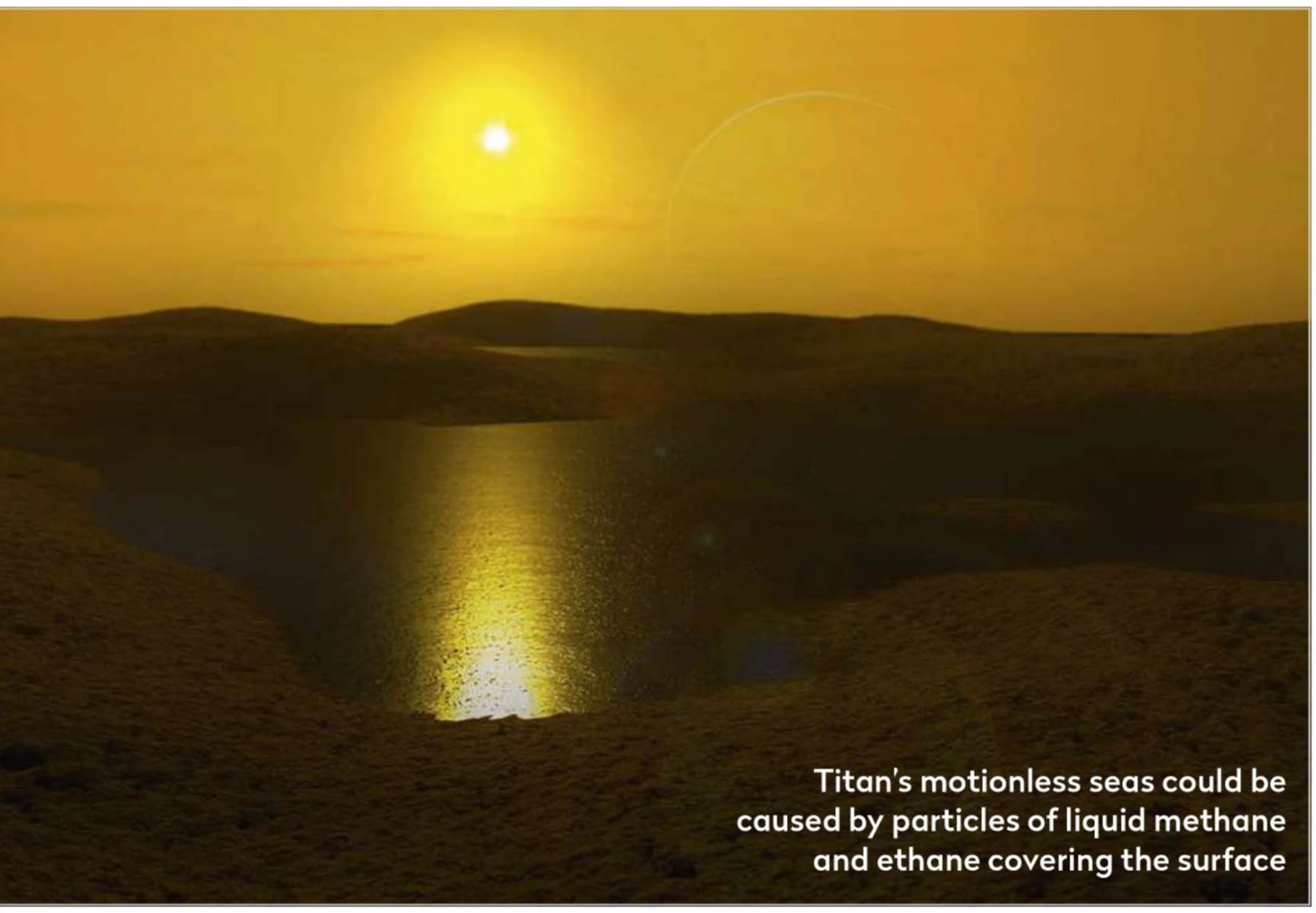
Stable tripod

The stainless steel tripod and the locking clamps of the mount provide excellent stability. The tripod can be extended out to 102 cm in length.

	Article No.	Price in £
ProNewton 153/900 incl. EQ-500 X Drive		
Weight 22.75kg	59378	**590.00**
ProNewton 153/750 incl. EQ-500 X Drive		
Weight 22.75kg	59379	**600.00**
ProNewton 203/1000 incl. EQ-500 X Drive		
Weight 26.5kg	59380	**700.00**

Coming Soon

"Summer 2019, the mount will also offer GoTo capability and auto-guiding via USB for successful astronomy photos. Slew to objects directly from your PC. Update free for all purchasers of this mount. Optional: Use the StellarMate, ASIAIR or a similar device to transform your EQ-500 X Drive into a wireless GoTo mount and control it from your phone or tablet!"



Titan's motionless seas could be caused by particles of liquid methane and ethane covering the surface

Why are Titan's seas waveless?

Oil on the lakes and oceans of Saturn's largest moon could be keeping them calm

Titan is one of the wonders of the Solar System: a giant moon of Saturn even larger than the planet Mercury, and the only world beyond Earth to sport liquid seas on its surface. These seas of liquid methane and ethane were observed by the Cassini spacecraft in 2006, but space scientists noticed something decidedly odd about them.

Radar measurements by Cassini indicated that despite strong winds on the moon, the seas are flat to below the level of millimetres – they are practically mirror smooth. This would certainly make for a beautiful sunset view standing on the shores of, say, Kraken Mare. But it also raises an important question. If Titan does have surface-level winds, why aren't they raising any waves, or even detectable ripples?

The answer, reckon Daniel Cordier and Nathalie Carrasco, is that Titan's seas are covered in the equivalent of oil slicks.

It's long been known on Earth that an oil film damps sea surface waves – Aristotle noticed the effect over 2,000 years ago, and more recently we've come to understand the process involved. Wind blowing over liquid creates waves in a two-step process. Firstly, small turbulent variations in the airflow give rise to tiny ripples on the surface. These then get larger and larger, becoming into full-blown waves in a feedback process – a wavelet catches more airflow on its windward side and grows, to catch more air, and so on. However, even a thin film on the surface can hinder the generation of those first tiny ripples, and so block the formation of waves before they even get started.

Titan is known for its thick, globe-enshrouding haze layer. This is made up of tiny solid particles of organic material, created high in the atmosphere by solar ultraviolet light, that then settles slowly to the surface. In humid conditions (around Titan's poles) these aerosol particles may serve as nucleation cores for droplets of liquid methane to form around, mirroring cloud and rain formation from water in Earth's atmosphere. These organic particles could either drift down to the ground dry, or be delivered within raindrops, but either way would make it to the surface and the lakes.

Radar measurements indicated that despite strong winds, Titan's seas are flat and practically mirror smooth

While Cordier notes that most of the likely aerosol particles are denser than liquid methane and ethane, and would simply sink to a sludge on the sea floor, there is an important effect that could keep them floating on the sea surface. Something called capillary force allows even dense objects to float on the surface if they are coated with a substance that repels the liquid. For example, the feet of some aquatic insects are 'hydrophobic' and allow the animal to walk on water due to the surface tension. Cordier argues that the chemistry of some aerosol particles on Titan would mean that they similarly repel the methane and ethane, and so remain floating on the sea surface. This forms a film, which prevents wind-blown ripples from forming into waves.

If Cordier is right, it means that, astonishingly, Titan's seas are waveless and mirror-smooth because they are smothered with fallen aerosols that settle because of the pond skater effect.

Prof Lewis Dartnell is an astrobiologist at the University of Westminster and author of *Origins: How the Earth Made Us* (geni.us/origins)

Lewis Dartnell was reading... *The floatability of aerosols and waves damping on Titan's seas* by Daniel Cordier and Nathalie Carrasco.
Read it online at arxiv.org/abs/1905.00760

KEVIN GILL/FLICKR

A kilonova would outshine any star

If two nearby neutron stars collided, they could be seen in the middle of the day

Prof Chris Lintott is an astrophysicist and co-presenter of *The Sky at Night* on BBC TV. He is also director of the Zooniverse project

Right now, it seems like the whole astronomical world is talking about dramatic events called kilonovae. These cataclysmic explosions are among the most luminous in the Universe. Easily capable of outshining an entire cluster of galaxies, it's perhaps fortunate that they occur at great distances – the most famous recent event, GW170817, detected by optical telescopes and by the LIGO gravitational wave observatory was more than 130 million lightyears away.

Despite this enormous distance we've learnt a lot about kilonovae. When a star larger than the Sun (but smaller than about 10 solar masses) reaches the end of its hydrogen-burning career, the result is a dense remnant known as a neutron star. These are extreme objects. The mass equivalent of two Sun's worth of material is crammed into a volume roughly 10km across; a teaspoon's worth of neutron star material would weigh 10 million tonnes. We see some of them – when the geometry is just right – as pulsars, but otherwise the 100 million or so neutron stars in the Milky Way live out quiet lives.

Until, that is, just occasionally two of them collide. That's what seems to trigger the immense power of a kilonova. A nearby example would be sure to be spectacular – but how spectacular? That's the question that occurred to the authors of this month's paper, Nihar Gupte and Imre Bartos of the University of Florida. They decided to consider such an event taking place 1,000 lightyears from Earth and started to work out how to image it. Only one such event should take place every 100 million years, but half the battle of astrophotography is being prepared.

Thanks to recent efforts to observe events like GW170817 we now have a good idea of the spectrum of such kilonovae. This changes over time, as an explosion which is initially brightest in the ultraviolet becomes redder over time as the gas expands and cools. Taking into account the sensitivities of the cells in the human eye, witnesses to such an event would see a brilliantly blue bright star, but by the next night it would already appear orange, and a week or so in, a deep red colour.

It's the brightness that stands out. Such an event would outshine every other star in the sky, being clearly visible at midday for days after its peak in brightness. Astrophotographers will struggle to capture a nice, clean stellar image and so the simulated images in the paper – one of which is printed here – include the effect of such a bright source in a normal camera, using a 1 second exposure.

The results are spectacular. Despite all the careful work the authors have done to make their simulation realistic, there's something uncanny about such a bright star hanging in the sky. The images fail to look realistic, because none of us has ever seen anything like this. Imagine the reaction around the world – what this paper makes clear is that even those who normally ignore the sky would be impressed by the brief and spectacular destruction of a couple of neutron stars.

Witnesses would see a brilliantly blue bright star, but after a week or so it would appear a deep red colour

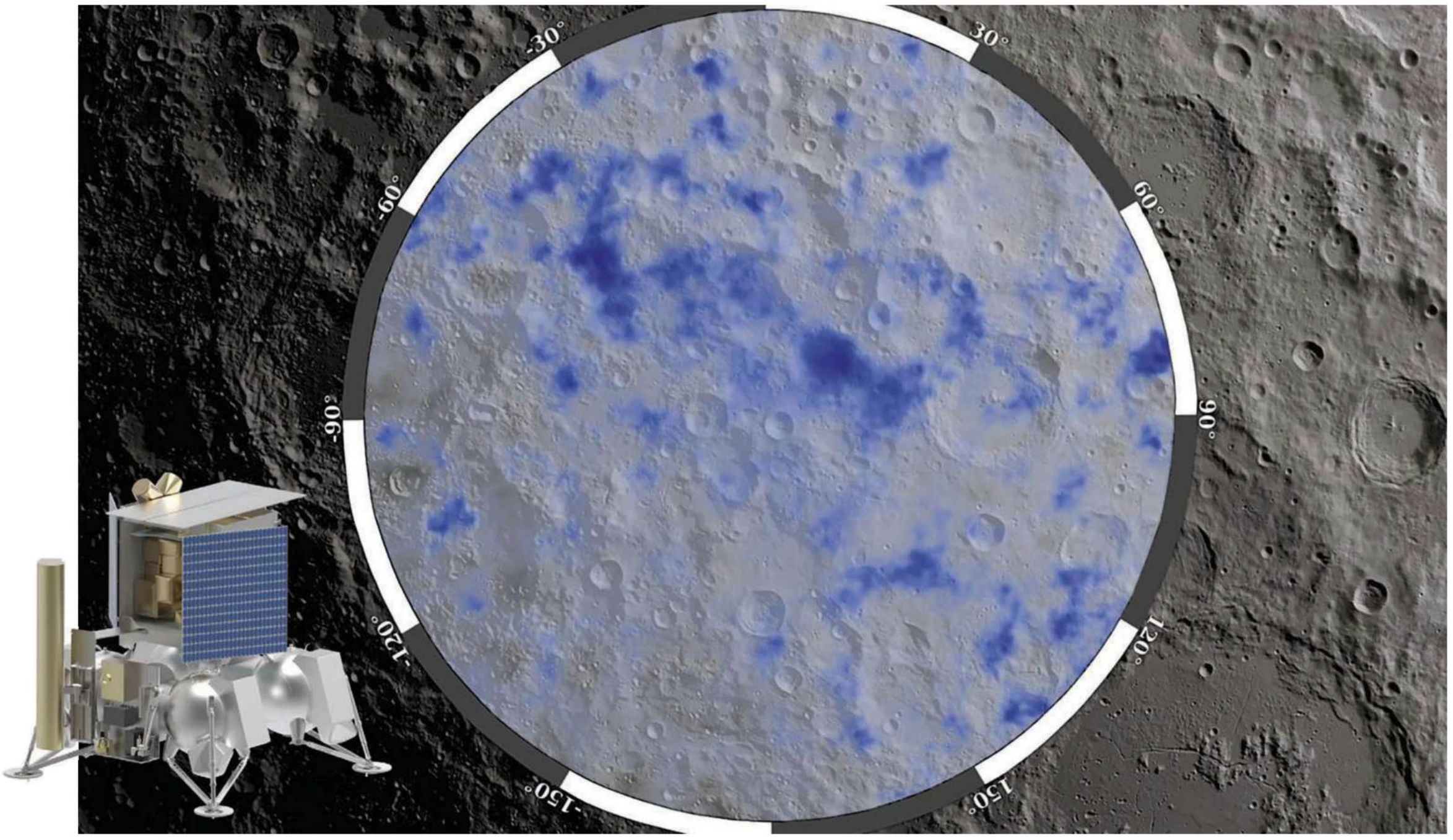
Day one: an imaginary view of a bright kilonova over New York

Day seven: the red kilonova is still visible in the sky

Chris Lintott was reading... *How would a nearby kilonova look on camera?* by Nihar Gupte and Imre Bartos.
Read it online at arxiv.org/pdf/1905.01594

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT



▲ **By drilling under the lunar surface, the PROSPECT mission (inset) will build on satellite data that has located areas where high concentrations of frozen water could exist (shown above in blue)**

NASA'S GODDARD SPACE FLIGHT CENTER, OPEN UNIVERSITY, NASA X 2

In June *The Sky at Night* looked at plans to return to the Moon and spoke to **Dr Simeon Barber** about working on the PROSPECT mission. Here he tells us about how it will tap into lunar resources

The first Space Race ended 50 years ago with Neil Armstrong's 'giant leap'. But now a new race is underway with many new entrants. Space agencies, commercial companies and collaborations of the two, are set to land multiple spacecraft in previously unexplored places on the Moon. A new international space station may be established in lunar orbit, and we may well see humans return to the surface of the Moon.

There are many compelling reasons to go back: scientific opportunity, a desire for exploration, and favourable commercial and political factors. A common theme is the growing realisation that the Moon may contain much more water than was previously imagined.

Finding this water, and understanding where it came from and how it is processed could be a game-changer for exploration. Harvesting lunar water to supply human bases and to produce rocket fuel could reduce our dependence on lifting supplies out of Earth's clinging gravity field.

At The Open University, my team is helping to develop a resource prospecting tool named PROSPECT for the European Space Agency. Its job is to extract samples from the lunar surface and analyse them in situ, transmitting the data back to Earth.

Return to the Moon

PROSPECT's first mission will be on board Russia's Luna-27 spacecraft scheduled to launch in 2024. Its near-polar landing site is expected to be very different from the more equatorial regions visited in the 1960s and '70s. Throughout the lunar day (lasting around 29 Earth days) the Sun is never more than a few degrees above the horizon: the ground will be colder with elevated levels of water ice and other frozen molecules.

Samples will be collected by a drill from up to a metre or so below the surface, and delivered to a miniature analytical laboratory containing microscopes and mass

Dr Simeon Barber leads development of ProSPA at The Open University, the instrument that will analyse samples drilled by PROSPECT

spectrometers. The data will make it possible to identify and quantify water and other volatiles in the samples, and how these vary with depth below the surface.

The results will provide a 'ground truth' for the global picture revealed from satellites in lunar orbit.

But any one lander, however capable, can sample only a tiny fraction of the Moon's diverse geology, so to get a truly global picture, we need multiple measurements from many missions. We are planning instruments on board rovers to create regional 'volatiles maps' – vital to understanding the Moon's science, but also valuable for those planning future missions to use these materials as resources.

We are designing an instrument for a NASA lander to track the movement of molecules across the lunar surface, from warmer equatorial regions to the colder poles. So, we are getting used to the idea of a Moon rich in water and starting to think of a water cycle happening there right now. We'd like to put instruments into those polar areas that never see the Sun – the so-called Permanently Shadowed Regions where temperatures are –230°C or lower. For billions of years these 'cold traps' have been accumulating a historical sample of the volatiles in the Earth-Moon vicinity – a treasure trove of scientific significance and potentially a source of resources to sustain future exploration.

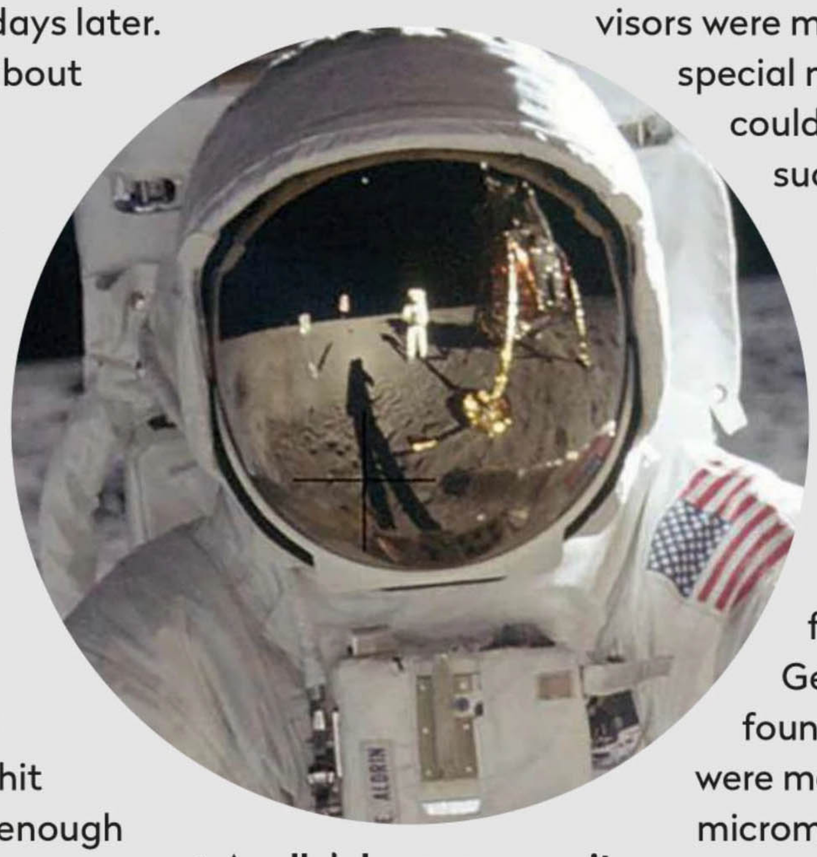
Looking back: The Sky at Night

July 1969

On the 15 July episode of *The Sky at Night*, 50 years ago, Patrick Moore looked ahead to Apollo 11, due to launch just two days later.

One concern about the landing was the threat from micrometeorites – small fragments of debris travelling through space at tens of kilometres per second. Though tiny, their incredible speed means they can hit spacecraft hard enough to dent the metal of the outer hull.

While they were on the lunar surface the astronauts had to rely on their spacesuits for protection.



▲ **Apollo's lunar spacesuits were made to withstand impacts from micrometeorites**

Fortunately, the suits had many layers so even if the outer ones failed, the inner ones would hold. Even the helmet visors were made from special material that could withstand such impacts.

In fact, the moonwalkers were probably safer than astronauts spacewalking while in Earth orbit. Tests from the Gemini missions found that there were many more micrometeorites near Earth, and an increasing number of them were man-made – just 12 years into the Space Age, space junk was already becoming a problem.

The Moon, the Mission & the BBC

To mark 50 years since the Moon landing, *The Sky at Night* tells the story of how the BBC reported on Apollo 11 at the time. Reporter James Burke recalls how he was given access to the Command Module for an episode of *Tomorrow's World*, and the UK's first astronaut Helen Sharman reveals whether predictions about what life in space would be like have come true.

BBC Four, **14 July,** 10pm (first repeat
BBC Four, **18 July,** 7.30pm)
Check www.bbc.co.uk/skyatnight for subsequent repeat times

▲ ***The Sky at Night*** **reveals how the BBC reported on Apollo 11 in July 1969**

Emails – Letters – Tweets – Facebook – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

This month's top prize: four Philip's books

PHILIP'S

The 'Message of the Month' writer will receive four top titles courtesy of astronomy publisher Philip's: Robin Scagell's *Complete Guide to Stargazing*, Sir Patrick Moore's *The Night Sky*, Mark Thompson's *Stargazing with Mark Thompson* and Heather Couper and Nigel Henbest's *2019 Stargazing*.

Winner's details will be passed on to Octopus Publishing to fulfil the prize

A moment in the Sun

The 'DIY Astronomy' project in the May issue of *BBC Sky at Night* (p72) arrived in perfect time for the Easter long weekend. I showed it to my partner as a project for him and today this beautiful sundial was complete. And it keeps to time – set to GMT. A beautiful complement to my modern scopes. Thanks very much for suggesting it.
Lori-Ann Ovore, via email

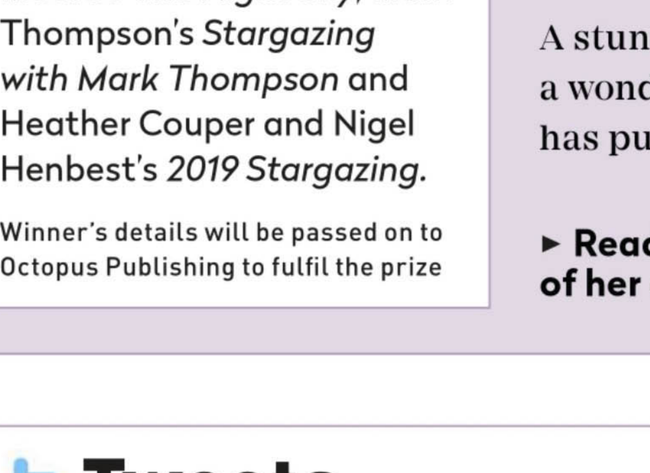
A stunning sundial, Lori-Ann. What a wonderful finish your partner has put on it. ***– Ed***

► Reader Lori-Ann is the proud owner of her own labelled 'portable sundial'

MESSAGE OF THE MONTH

Tweets

Siv Heang
@hoodoos84 • May 25
Wells Gray Provincial Park #road #darkhorse @bcliving @CalgaryRASC @EdmontonRASC @AstronomyMag @rasc @weathernetwork @hellobc @SkyNewsMagazine @skyatnightmag @AstronomyMag @AstroCanada @CTVdavidspence @NarcityCanada



Star speaker

On Tuesday 23 April Professor Dame Jocelyn Bell Burnell visited Ashfield School, Kirkby-in-Ashfield to present her lecture, 'Transient astronomy: bursts, bangs and things that go bump in the night'. This was organised by the Mansfield and Sutton Astronomical Society (MSAS) and Ashfield School. Dame Jocelyn, who appropriately enough is currently based at Mansfield College, Oxford, was presented with Easter presents by students from Ashfield and Heanor Gate Schools, and flowers from MSAS. The lecture was attended by nearly 100 and was well received, especially by the students who were excited to listen to a real scientist.
Richard Field, via email

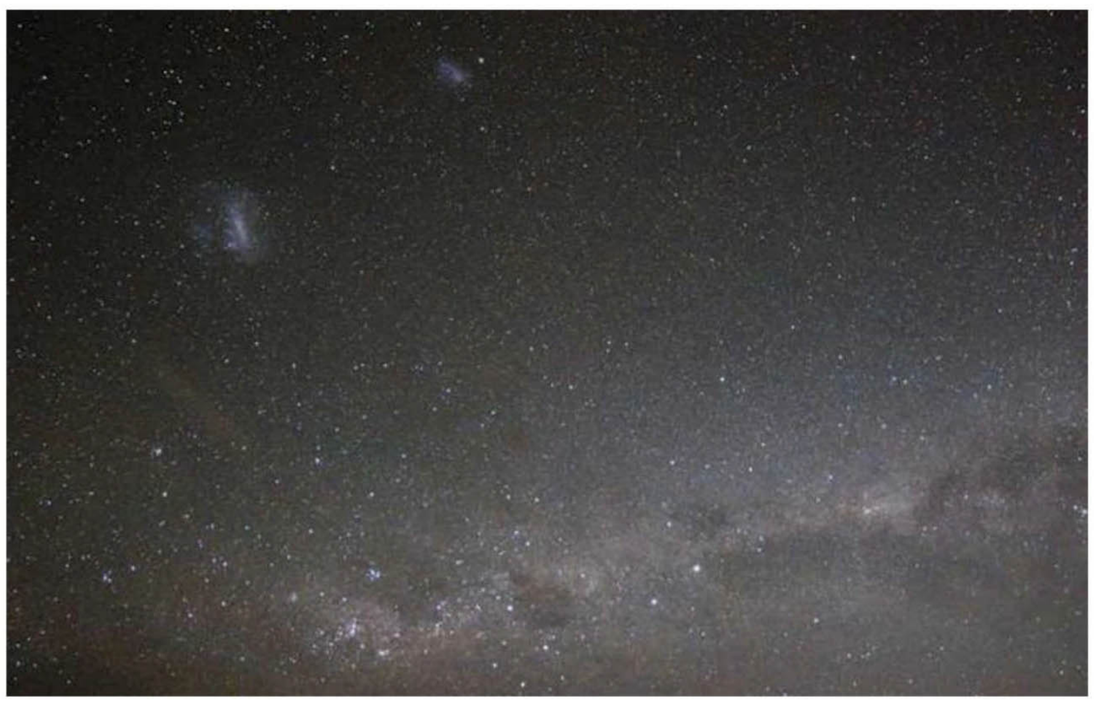
Global warning

How disturbed are we by the recent revelations on climate change and biodiversity loss? The message is that without immediate, drastic action we face irreversible damage to our planet within the next 20–30 years. What can be done? Personal, national and international actions (sacrifices) may mitigate or avert the threat. Should we divert space exploration and astronomical research into saving our planet? It would be small comfort to know more about the Big Bang, black holes and exoplanets if we are suffering from all the forecast effects of the 2-4° rise in global temperature. Astronomy has some of the best brains

and equipment, which could be focused on planet Earth and help to make a difference.
Dermot Stewart, Canterbury

Triple sight

I read with interest the letter by David Palferman ('Interactive', May). I also have been lucky in travelling around New Zealand. We were staying at Kaikoura and had a wonderfully clear night. We drove from the town centre around the headland up to a high point and found a good place to stop. As we both exited the car we were taken back with the incredible sky, so dark and clear. I set up my Sony A77V DSLR camera on a small tripod and took this photo of the Small Magellanic Cloud, Large Magellanic Cloud and the Milky May. It was a 25 second exposure at 3200 ISO with a wide-angle lens – a real treat, and what a sky!
Richard Jenkinson, via email ▸



ON FACEBOOK

WE ASKED: What are your top tips for getting kids interested in astronomy?

Gillian Rushforth
Keep a pair of binoculars to hand, then when there's a clear night you have a window of opportunity to show them the night sky. Take them outside with you and tell them stories about the constellations.

James Harrop
Show them the Moon, Saturn or Jupiter through a scope. These objects are visually interesting and awesome to look at, especially for the first time.

Manuel Jolink
Buy some cheap meteorites like small fragments of Campo del Cielo or Sikhote Alin and let them hold the rocks from space in their own hands.

Tony Moss
Take them to an astronomical outreach event so they can use the telescopes and chat to the astronomers.

Sonja Charters
Take them to places like the Observatory Science centre at Herstmonceaux in East Sussex – where there's loads of interactive activities for them to do. Why not try a midnight lie-out under the night sky in August looking for shooting stars?

Gaenor Black Drake
Watch the ISS pass over, and there's no specialist equipment needed. We used to have a huge Solar System jigsaw that my daughter used to jump on from planet to planet. She loved it and is now studying astrophysics!

Steve Green
Don't send them to bed at 8.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies
With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I struggle to move my telescope on my own. Is there anything that would make it easier?

HEATHER BAKER

▲ **Find a guide and plans to make your own dolly on our website**

The requirement for a sturdy mount and the weight of the telescope itself soon adds up to a substantial piece of equipment to move. Thankfully, there is a simple device called a tripod dolly to help you.

There are numerous manufacturers but be aware that some of the designs are intended for use on rails and are not suitable. For astronomy purposes where solid alignment is important, it's necessary to use a design that has either retractable feet, so that once the scope is rolled into position they can be lowered to lift the wheels off the ground, or substantial brakes to lock the wheels in position.

The JMI Universal telescope trolley or Manfrotto 114 heavy duty tripod dolly are good choices. For a guide to making your own dolly and printable plans visit **www.skyatnightmagazine.com/advice/build-a-rolling-telescope-dolly/**

Steve's top tip

What is a Barlow lens?

A Barlow lens is an optical tube containing lens elements that diverge the light passing through them. Inserting a Barlow lens into the light path of any type of telescope increases the effective focal length, usually by doubling it, although some designs have an even greater effect.

You can calculate the magnification of a telescope by dividing its focal length by the focal length of the eyepiece. This means that an increase in the effective focal length of the telescope results in an increase in magnification. So using a Barlow lens effectively doubles the number of eyepieces that you have in your collection!

Steve Richards is a keen astro imager and an astronomy equipment expert

MARK PARRISH

BBC Sky at Night MAGAZINE

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abc Audit Bureau of Circulations
19,202 (combined; Jan–Dec 2018)

ISSN 1745-9869

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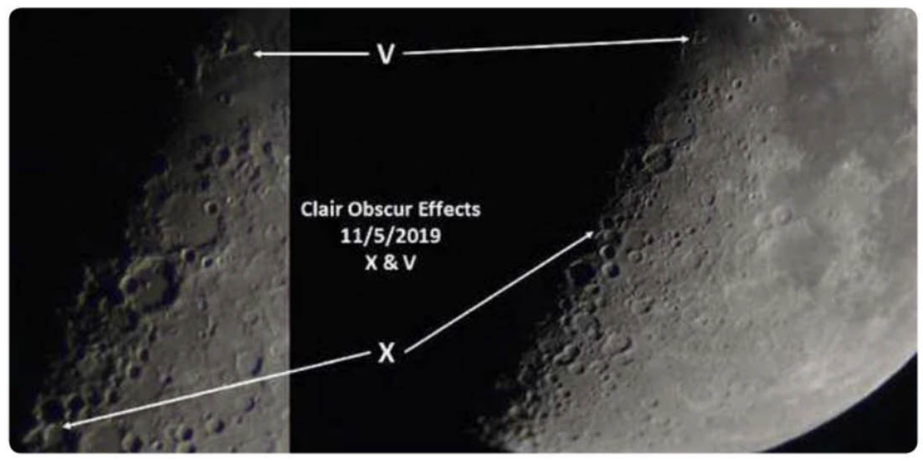
clair obscur effect X and V. Last night. @skyatnightmag @BBCStargazing @CardiffAS



Hole story

▸ I teach physics and astrophysics at the English Gymnasium in Stockholm, Sweden and following the black hole announcement before Easter, I set an exercise for some Year 10 students (17 year-olds): "As most of you were aware, last week saw the most detailed picture ever taken of an object in space, namely the black hole at the centre of galaxy M87. Write a news release or short article for our school magazine/website."
Here is one contribution to the lesson:

Hot off the press – monster black hole: the first image
"In a galaxy far, far away
A black hole was seen yesterday.
A remarkable feat for humankind,
Blowing every scientist's mind.
Eight telescopes were needed to see
the hole
One being placed on the southern pole.
The picture was captured using
radio waves,
Perhaps the most high definition image of our age.
The black hole was located in M87
And now we're singing praises to Einstein in heaven!"
I thought you might like to share!
Jonathan Richardson, Stockholm

Seeing stars in 3D

If two photos were taken of the same star field but six months apart and these were seen in a stereo viewer would it be possible to discern the stars in 3D? If the parallax at 300,000,000km apart is not sufficient, then could an Earth view be used with one from Voyager (1 or 2) to give the desired effect?
Chris Webster, New Malden

SOCIETY IN FOCUS

COSMOS is a group of amateur astronomers based on St Martin's, Isles of Scilly. Our Friday afternoon sessions are proving very popular for solar viewing, with visitors discovering that astronomy can happen in daylight. Our Coronado SolarMax III 70 telescope, with its hydrogen alpha filter, offers clear views of the Sun and its activity – cloud permitting.

On 25 May, we welcomed children from the local St Martin's primary school. The sky was partly cloudy for the first part of the session, so we had a good look round the observatory and at several images of the Sun taken on previous occasions – including a solar prominence.

When the clouds cleared, we took it in turns at the SolarMax. It was the first time any of our visitors had seen the Sun with the naked eye and it was exciting to look at it up close, especially as we spend a lot of time at school making sure children know never to look at the Sun with the naked eye.

The children could make out the texture of the Sun's surface, with a few 'wows'! Back in the warm room we talked about why learning about the Sun is important: its activity can help us learn more about stars and affect our life here on Earth.

We recruited some new budding astronomers, and it was great to appreciate the wonders of our nearest star together.
Charlie Payne, Secretary, COSMOS
▸ Solar-gazing at COSMOS, Community Observatory St Martin's on Scilly, runs every Friday, 2–4pm. For more information visit cosmosscilly.co.uk

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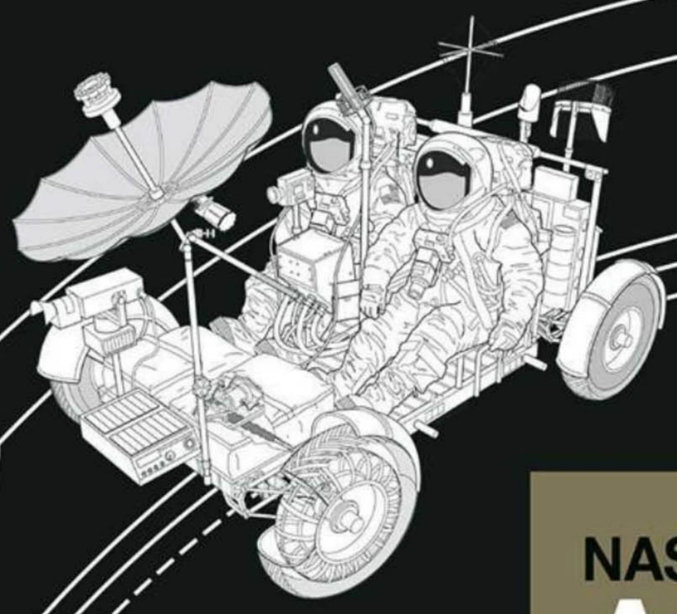

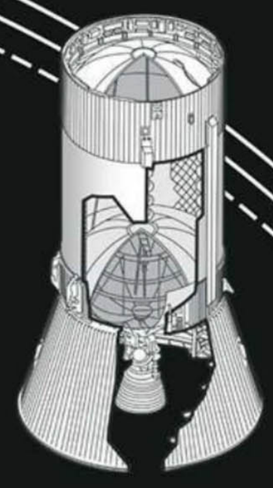

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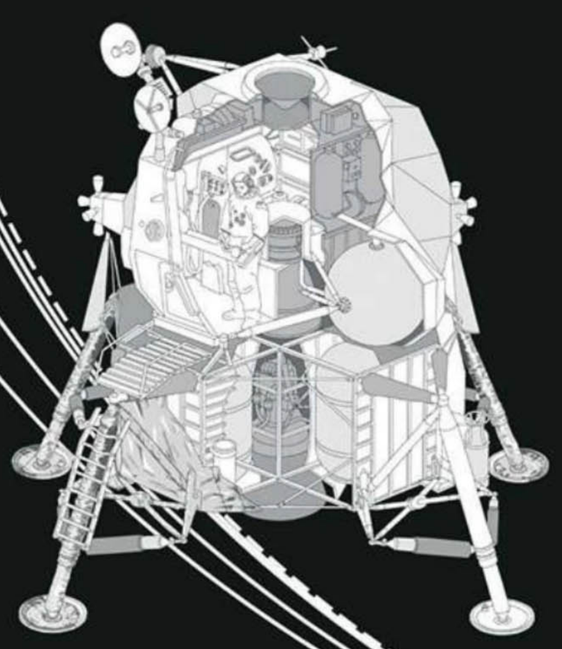
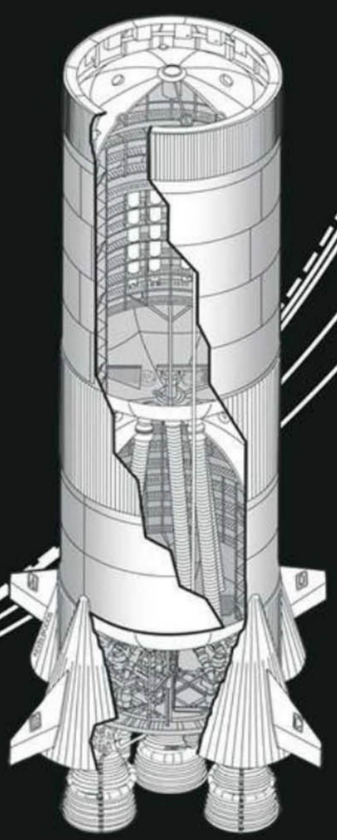
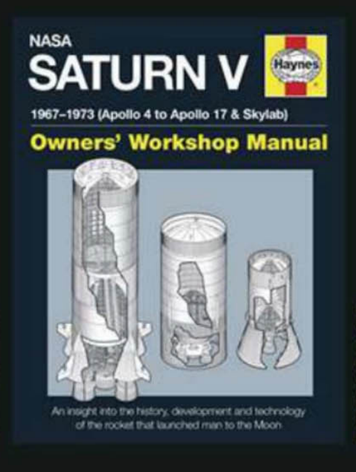


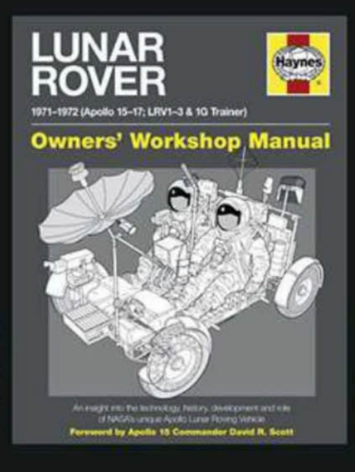
CELEBRATE

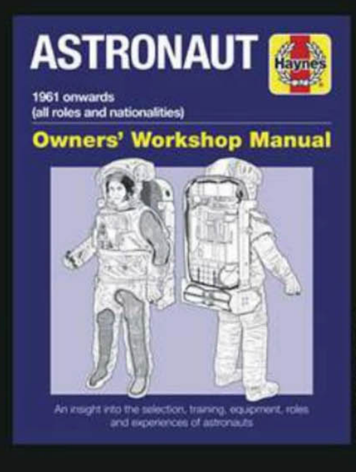
50 YEARS

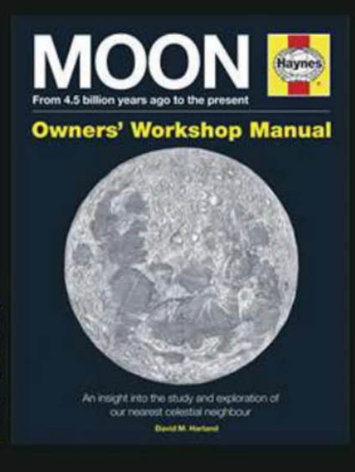
SINCE THE FIRST MOON LANDING WITH HAYNES

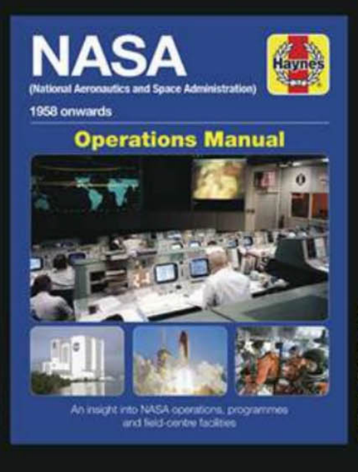












HAYNES.COM/SPACE

Our pick of the best events from around the UK

WHAT'S ON

Apollo Astronight

The Science Museum, London,
20-21 July, 7pm–10am

A cosmic sleepover, with a range of activities including a lunar rover workshop and interactive drop-in sessions. Families only, age 7-13. Tickets are £85. For further information and to book visit **www.sciencemuseum.org.uk**

Preseli astronomy meeting

Letterston Memorial Hall, Haverfordwest,
2 July, 7pm–9pm

Join the Preseli Astronomy Group for an evening of stargazing (weather permitting) and guest speakers. Entry is free, although donations are appreciated.
www.preseliastronomygroup.org.uk

Stargazing Saturday

The Astronomy Centre, Lancashire,
6, 13, 20, 27 July, 7.30pm–11.30pm

The Astronomy Centre hosts an evening of stargazing through telescopes and an astronomy talk. Please note that this event is weather dependent.
www.astronomycentre.org.uk

Partial lunar eclipse in Bath

Herschel Museum of Astronomy, New King Street, Bath, 16 July, 8.30pm–11pm

Join Bath Astronomers for an evening of stargazing and a chance to see a partial lunar eclipse from the garden in which Uranus was discovered! Tickets £10, £7 concessions, £4 children. Book online at **herschelmuseum.org.uk**

Apollo 11 celebrations

Yorkshire Air Museum, York,
21 July, 10am–5pm

Celebrate the 50th anniversary of the historic Apollo 11 Moon landing at the Yorkshire Air Museum. Activities include a projection of Moon landing footage, a variety of space talks and the chance to build your own rocket. For ticket prices and further information, visit **yorkshireairmuseum.org**

Observatory open day

Mills Observatory, Dundee,
6, 20, 27 July, 12.30pm–4pm

Tour the night sky and learn all about constellations, asteroids and more. Tickets are £1 for adults, 50p for children. Booking essential: call (01382) 435967.
www.leisureandculturedundee.com

BLUEDOT FESTIVAL X 4, SCIENCE MUSEUM GROUP

PICK OF THE MONTH

▲ **This year's Bluedot festival is all about Apollo 11 (with a side order of *The Clangers*)**

Bluedot 2019

Jodrell Bank Observatory, Cheshire, 18-21 July

The Bluedot science and music festival returns to Jodrell Bank for a fourth year. This year, Bluedot celebrates the 50th anniversary of the Apollo 11 mission, with an impressive Moon-themed programme spanning music, science and culture.

Festival-goers can attend a range of captivating talks with a line-up including the UK's first astronaut Dr Helen Sharman, broadcaster Dallas Campbell and the UK Space Agency's human spaceflight expert Libby Jackson. You'll be able to relive the Moon landing in style with an audio-visual spectacle created by light artists Illuminos across the canvas of the Lovell Telescope dish, while music lovers will appreciate a range of Moon-themed performances by artists including Easy Star All-Stars, The Radio Science Orchestra and classical-infused art-rock trio Stems.

Alongside Apollo 11, Bluedot will also be commemorating *The Clangers*' 50th anniversary and the 30th anniversary of the first Wallace and Gromit film. For more information on tickets, camping and the full 2019 line-up, visit **www.discoverthebluedot.com**

WE HAVE LIFT-OFF!

Man on the Moon 50th Anniversary

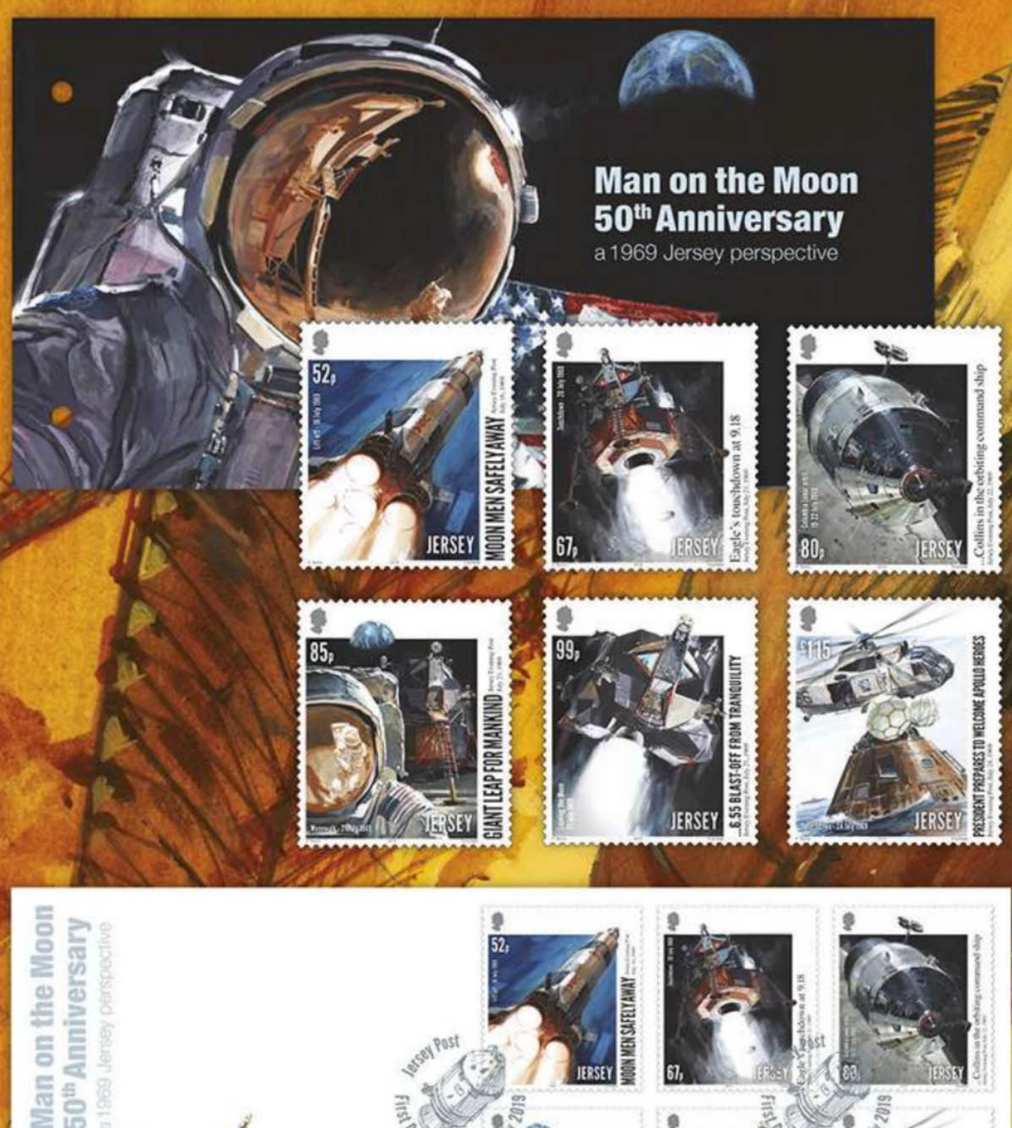
a 1969 Jersey perspective

Relive the historic moon landing with these fascinating collectables from Jersey Post.

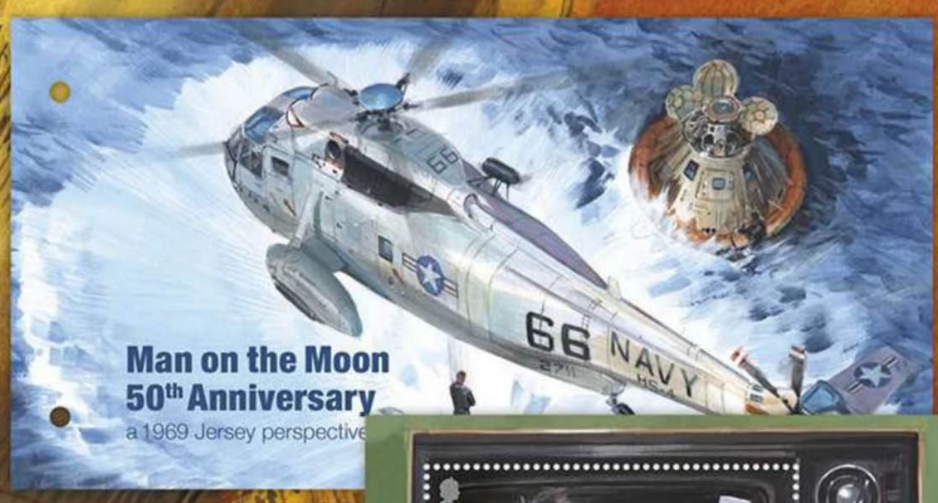
The Apollo 11 lunar mission is remembered as one of the world's most significant historical events. On 20th July 1969, man's first landing on the surface of the moon was watched on television by an audience of over half a billion people worldwide. Television, radio and newspapers broadcast and reported on each day of the mission and this was the same in the Channel Island of Jersey.

Six stamps and a Miniature Sheet, illustrated by acclaimed aviation artist Keith Burns, depict key parts of the mission, together with a newspaper headline or quote as reported by The Jersey Evening Post.

Stamps Presentation Pack - £6.13 + VAT



Miniature Sheet Presentation Pack - £4.15 + VAT



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FIELD OF VIEW

And now back to the studio...

In 1969, **Sir Patrick Moore** was part of the BBC's Apollo 11 commentary team. In 2009, he described his part in the historic live broadcast

ALEX GREEN/FOLIO ART

Sir Patrick Moore presented *The Sky at Night* from 1957–2012 and was Editor Emeritus of the magazine from 2005–12. His lunar maps were used by both the American and Russian space agencies to plan their Moon missions

Since I had been mixed up in the observation of the Moon for many, many years, I was the astronomer on the scene for the coverage of the Apollo 11 mission. When we came to anything to do with astronomy or the Moon, it would be my cue to commentate. I remained in the studio throughout the mission, with James Burke, who commentated on the mechanical side of the mission, and Cliff Michelmore, who did the general commentary. And there was also the usual team buzzing around: cameramen, sound men, assistant producers and secretaries.

On the night of the Moon landing, I was nervous. At the time, there was a lot of debate about the lunar surface and whether it was covered in soft dust or whether it was solid. I'd always been sure that the lunar surface was firm, and we knew something of the nature of the surface from the Russian and American landers, but there was still some doubt there. The point is that they couldn't have been rescued; if they had made a faulty landing there would have been no return.

When I heard Neil's voice coming through – "The Eagle has landed" – I felt immense relief. My main thought was that they were down safely and that the worst was probably over. However, it didn't end there. The other thing that made me very tense was when they blasted off from the lunar surface. There was only one ascent engine on the lunar module, and that had to work properly first time; luckily it did. Because I was busy commentating I didn't have time to celebrate then, but I had a large drink after the programme had finished.

The TV pictures that came back from the Moon looked very grainy and rough, but they were amazing for the time. They gave a very good impression of what it was like to be there, and it was just as Buzz Aldrin described in his famous phrase "magnificent desolation", which really hasn't been bettered. That's really what it was.

When it came to the moonwalks, I believed in saying as little as possible. I wanted people to watch the historic event without interruption, and I didn't want to talk over the astronauts. If they started talking while I was talking, I stopped, even if I was in mid-sentence. I was very careful about that.

Apollo 11 didn't do a lot of science, but it confirmed what the Moon was like and it proved that we could travel to other worlds. I remember looking at the Moon through my telescope during the mission and thinking that it was amazing that there were people up there on the Sea of Tranquillity.

I was immensely enthusiastic about Apollo, but I think NASA was right to call it off at 17. I don't believe the cancelled missions would have added much more to our understanding, and there was bound to have been an accident sooner or later. But I'm very glad to have been involved in the coverage, even in a very minor capacity.

This article originally appeared in the Man on the Moon *special issue*

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BBC Sky at Night MAGAZINE

The Blue Marble: this famous image taken by Harrison Schmidt during the Apollo 17 mission in 1972 inspired environmental awareness

Left: Neil Armstrong and Buzz Aldrin win the Space Race for America, by reaching the lunar surface on Apollo 11 in 1969

How Apollo changed the WORLD

Nick Spall looks at the wider legacy of Apollo and considers when we might return to the Earth's nearest neighbour

Reminiscing back to half a century ago, it seems remarkable that NASA was able to successfully land two men on the Moon on 20 July 1969, a mere eight years after Yuri Gagarin first orbited Earth and only 66 years after the Wright brothers mastered powered flight.

Historians in 1969 had little idea of whether Apollo would change the world. Indeed, on the night of the Apollo 11 landing, British historian AJP Taylor stated in a TV interview that he doubted that the event would make any difference to the course of human history. But it seems clear now that, in fact, the six Apollo Moon landings did alter the world in very many ways, covering the short, medium and indeed long term.

The decision by the United States to land on the Moon before the end of the 1960s was born out of the ideological Cold War with the then Soviet Union, which had been ongoing since the 1950s.

When President Kennedy addressed Congress on 25 May 1961 seeking support for the Apollo project, he spoke of how the US had to compete technologically and politically during the ongoing Cold War, saying: "If we are to win the battle that is now going on around the world between freedom and tyranny... it is time for a great new American enterprise." ▸

NASA X 2

▸ Kennedy took the initiative, realising that there were geopolitical and economic reasons to invest government resources in advanced technology – eventually over 400,000 Americans would work on the Apollo programme. The Moon Race became a test of ideological systems; indeed, Apollo 8 astronaut Frank Borman described his December 1968 flight around the Moon as, "a battle in the Cold War".

The Space Race is on

By spending a peak of over 4 per cent of its federal budget on space in 1965 and 1966, the US gained huge geopolitical and economic prestige. The USSR had committed approximately half the US funding level, but had failed in its own attempts at a Moon landing project, which had started in 1963 in response to Apollo. The US success saw the nation through the dark days of the Vietnam war to the early 1970s.

Arguably, Apollo changed short and medium term geopolitical and economic history between the 1970s and 1990s. By 1991 the Soviet Union had collapsed, ending the Cold War. There is no doubt that the Apollo programme, undertaken openly for the world, had strongly contributed to the outcome of this superpower battle. It was, according to many political commentators, like "fighting a war without direct casualties."

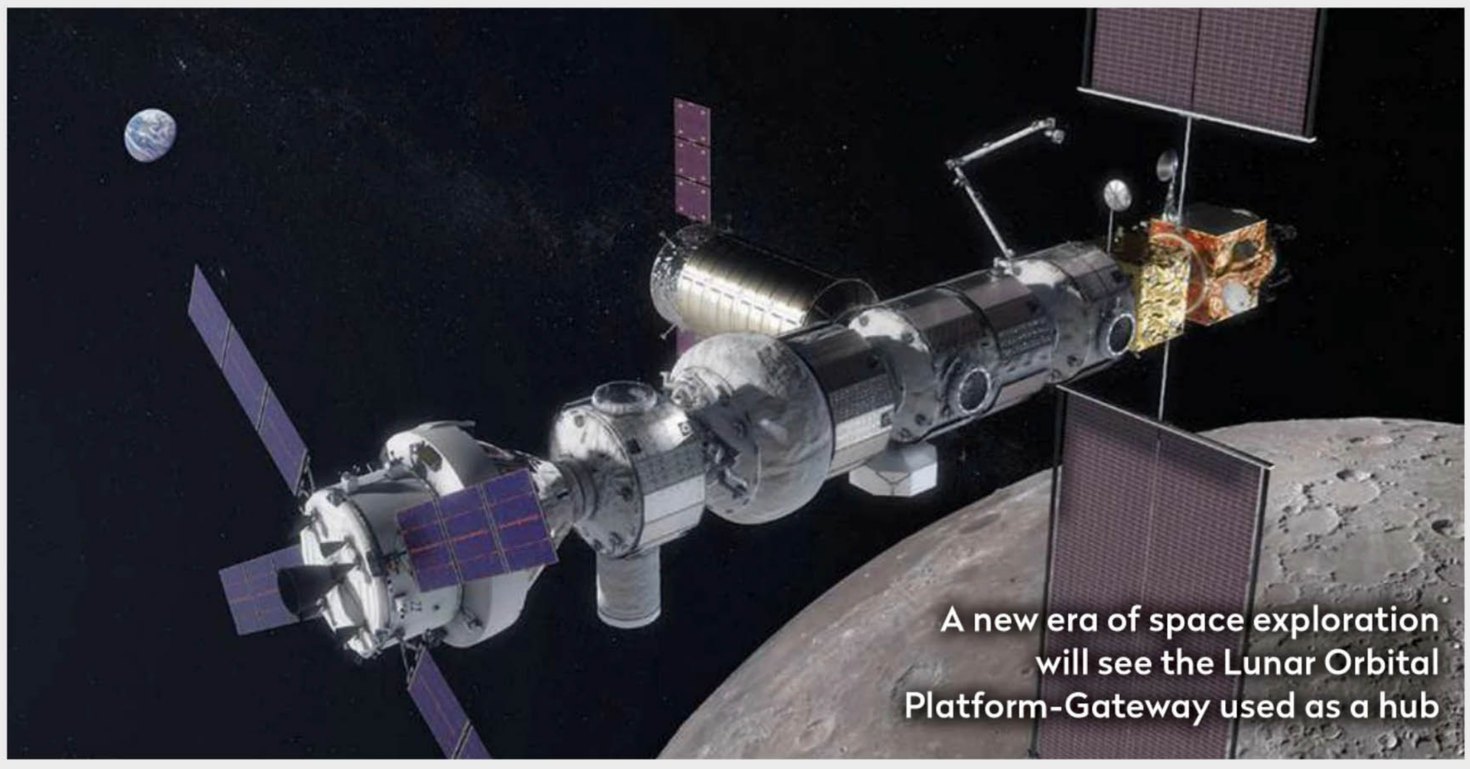
▲ **Moon talk: in 1962 President Kennedy announced his plans for sending American astronauts to the Moon**

There was more to Apollo than political posturing, however. In Kennedy's historic 1962 'we choose to go to the Moon' speech he said Apollo could "in many ways hold the key to our future on Earth". Futurist space writers like Konstantin Tsiolkovsky, HG Wells, Olaf Stapledon and Arthur C Clarke had always proposed that humanity's early exploration of the Solar System would represent a new destiny in the evolution of *Homo sapiens* as a species.

Armstrong's carefully crafted words, "one giant leap for mankind", recognised the symbolic change

Return to the Moon

The last decade has seen a renewed interest in returning to the Moon



A new era of space exploration will see the Lunar Orbital Platform-Gateway used as a hub

Apollo cost $160bn at today's prices. Due to huge US spending on the Vietnam War, social deprivation and other concerns at home, in 1972 President Nixon cancelled the last three planned Apollo missions.

Saddened at the cuts, Arthur C Clarke said at the time: "The Solar System was lost, at least for a while, in the paddy fields of Vietnam," but then later noted, "in the long perspective of history, a few odd decades of delay does not really matter."

Post-Apollo ambitions, like NASA's Project Constellation Moon return plan, did not work due to lack of funding, but in the last five years there has been renewed interest across the world, fired by water-ice discoveries at the lunar poles.

Following President Trump's Space Policy Directive 1 in 2017, NASA is developing the Lunar Orbital Platform-Gateway space station, with European, Japanese and Canadian support. Landing missions may occur by the late 2020s. Recently, Vice President Mike Pence called for a US return to the Moon as early as 2024 – an endeavour now called the Artemis mission. Though President Trump has requested an additional $1.6 billion to NASA's 2020 budget, many at NASA consider this too much of a challenge, and 2028 is probably the more realistic date.

The driving phrase from space agencies now is, "this time we will stay"!

▲ **The Apollo landings inspired a new awareness of our environment here on Earth, giving a huge boost to the Green movement**

that was happening at this time. After two million years of the evolution of *Homo sapiens*, humankind had reached the stage of being able to travel across interplanetary space – it had become a spacefaring species. Tsiolkovsky's deep words, "the Earth is the cradle of humanity, but one cannot live in the cradle forever", were being fulfilled.

Yet, rather than making us look out at our future beyond our planet, perhaps one of the programmes most lasting legacies was changing how we looked at our own planet.

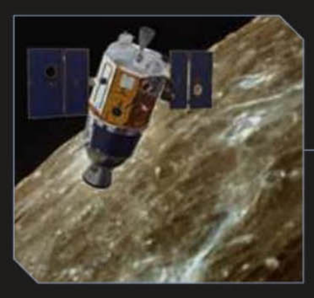
During the Apollo years of 1968-72, worldwide environmental concerns became evident. Pressure groups like Friends of the Earth and Greenpeace were established, while a report titled 'The Limits to Growth' set out what would happen to the planet should the population continue to grow and expand unchecked. Environmentalist James Lovelock created his Gaia theory, viewing Earth as a self-regulating biosystem.

A new perspective

We have Apollo to thank for the powerful motivational images of this vulnerable planet taken from 384,000km away. Astronaut William Anders's Earthrise photo from the 1968 Apollo 8 mission ▸

TIMELINE

The post-Apollo years



After Apollo

1976 Luna 24 returns limited soil samples to Earth

1990 Japanese Hiten orbiter

1994 NASA's Clementine observes the Moon

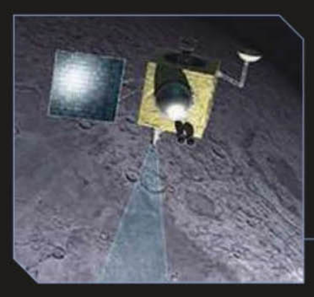
1998 NASA's Lunar Prospector orbits

2006 SMART-1, ESA orbiter; intentionally crashes

2007 Japanese SELENE orbiter

2009 Chinese Chang'e 1 orbits; crashed deliberately

2007–15 Google Lunar X prize challenges private companies to land on the Moon

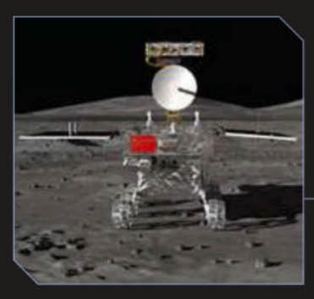


2008 Indian Chandrayaan 1 impacts – water discovered

2009 NASA's Lunar Reconnaissance Orbiter takes detailed survey

2015 International Moon Village idea promoted by ESA

2017 Space Policy Directive 1 plans for US return to the Moon



2019 Chinese Chang'e 4 lands on the far side

2019 Israeli SpaceIL Beresheet probe crashes during landing

The future?

2021 Luna-Glob, Russian polar lander

2023 Chang'e sample return missions

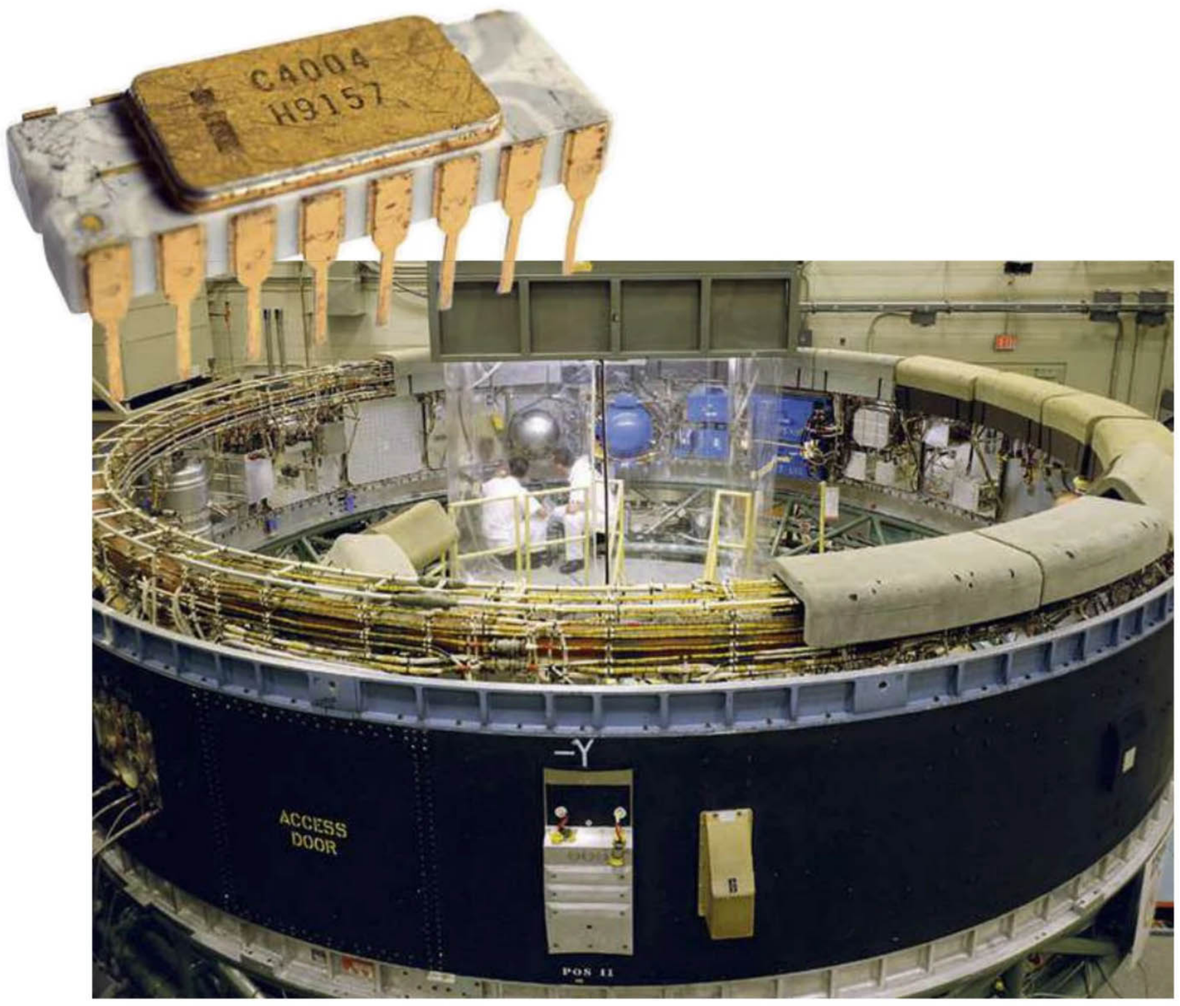
2023 NASA/ESA Orion manned orbital flight EM-2

2024 Potential SpaceX lunar missions

2028 NASA-led Moon orbiting station, the Lunar Orbital Platform-Gateway

2030 International lunar outpost or village established at the South Pole. Partly self-sustaining via in situ resource utilisation

2030–40s Lunar water for fuel and air, accelerating future exploration of Mars and the Solar System



▲ **The success of the technology used in the instrument unit on the Saturn V led to the birth of the first Intel microchip (inset)**

▲ **Neil Armstrong training with the Apollo Guidance Computer, which allowed him to land safely on the Moon**

► resonated with the public in an unexpected way. Allied to other images such as the famous Blue Marble whole-Earth photo taken by Harrison Schmitt in 1972, there was a striking change in our perception of the lonely Earth as an oasis of life in the cosmos.

As Anders said of the Apollo 8 mission: "We came all this way to explore the Moon and the most important thing is that we discovered the Earth".

Beyond this, an Apollo legacy must be the hope for future planet-wide initiatives. The global-level inspiration that the Moon landings provided means that projects like the reduction of carbon emissions could be seen now as more viable, provided nations followed the emerging 'we can land on the Moon and therefore achieve anything' approach, with sufficient financial investment. An example is the encouraging CFC reduction following a UN-led initiative – this used Apollo 17's Blue Marble image of Earth.

An age of invention

If the political will is there, similarly Apollo-inspired efforts might well help feed the planet, properly attack world poverty and disease, plus of course address CO_2 reduction internationally.

A key gift of Apollo, identified by space historian and film-maker Chris Riley, is the technological stimulus provided by the hi-tech nature of the NASA Moon programme. Many practical products developed by NASA during the Apollo years are well known – cordless drills, PV (solar) panels, freeze-dried food, thermal insulation material, heat coatings and so on. But Riley has also recorded how NASA approached Massachusetts Institute of Technology to develop a small, lightweight computer to fit into the Apollo spacecraft.

The computer used reliable integrated circuits and NASA placed an order for one million of them from the Fairchild Semiconductor company. This financial kick-start to the industry prompted two Fairchild employees to leave and form Intel in 1969. From this, the computer revolution of the 1970–2000 period developed, leading to small PCs, smart phones, the internet and dot-com industries. The technological gift from Apollo accelerated computer technology perhaps by 10–15 years, thanks to the knock-on effect within the industry.

Apollo also had a powerful inspirational effect on young STEM graduates across the world – there were three times more engineering and science PhDs following Apollo. Professors Brian Cox, John Zarnecki, Martin Sweeting and World Wide Web inventor Tim Berners-Lee have referred to the inspiration of Apollo, while space entrepreneurs like Richard Branson,

▲ **The Apollo Lunar Surface Drill (ALSD), being operated by Dave Scott while training for Apollo 15. Black & Decker helped develop tools for NASA to use**

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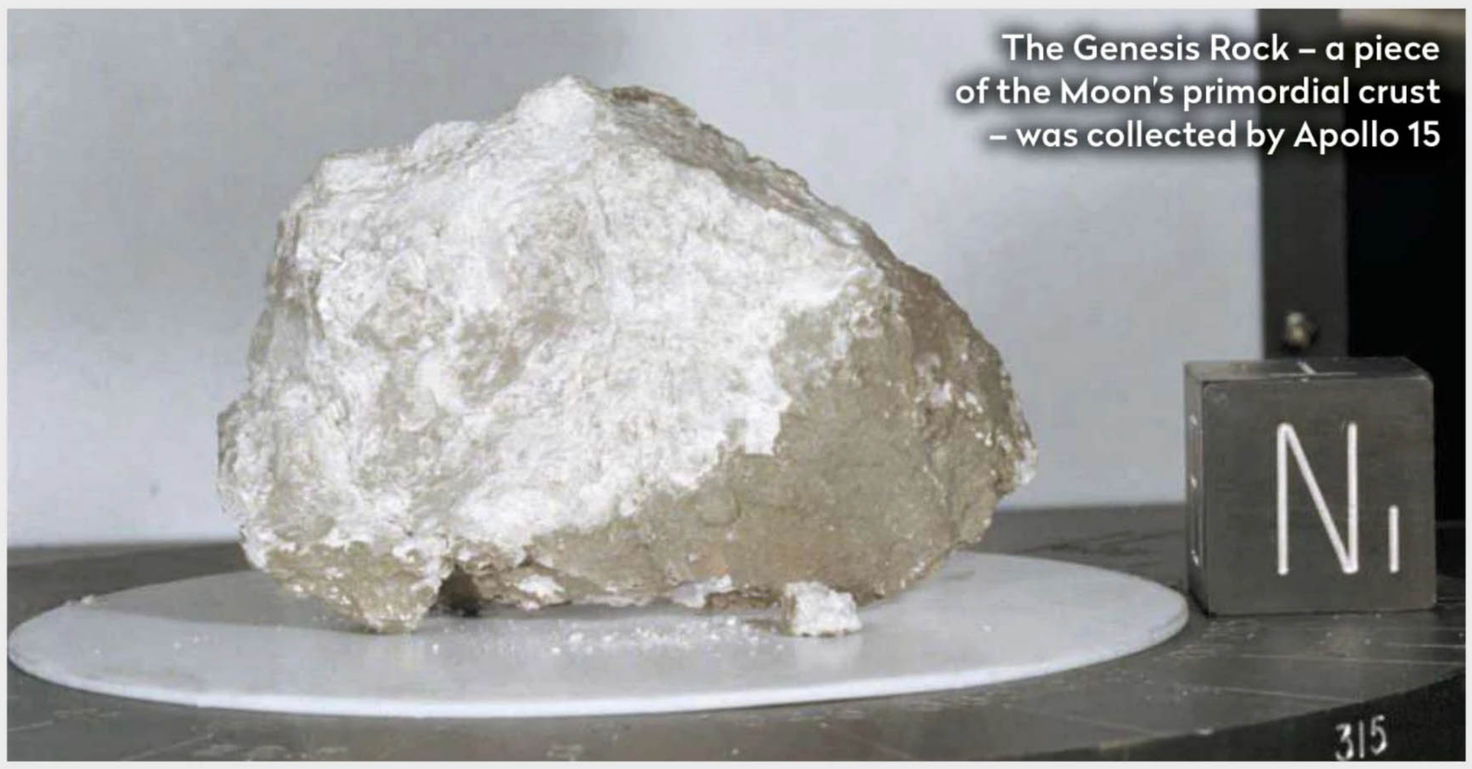
Apollo's scientific legacy



The Genesis Rock – a piece of the Moon's primordial crust – was collected by Apollo 15

Apollo started as a political ploy, but its missions made many discoveries

While the first three Apollo missions were intended as a precursor to fuller lunar exploration, Apollo 15 to 17 opened up a detailed geological study of the Moon. The crews found that the Moon has evolved over its 4.6 billion-year lifetime, being melted, erupting and impacted many times.

The Moon rocks brought back were similar in composition to Earth's, although lacking iron and elements that could provide an atmosphere. Samples as old as any on Earth were discovered, with the Apollo 15 'Genesis Rock' dating back 4 billion years.

Thanks to Apollo, lunar cratering is now better understood, and Earth, Mars, Venus and Mercury's cratering rates have been clarified. Lunar mascons – areas where the lunar mass is more concentrated – were discovered beneath lunar basins, originating from impacts 3.2–3.6 billion years ago. Theories explaining the difference between the thicker crust of the lunar far-side and the thinner Earth-facing side are now emerging.

As well as what the Apollo astronauts brought back in Moon rocks, scientists have learned from what they left behind, as laser reflectors placed on the surface by Apollo show that the Moon is slowly drifting away from the Earth at a rate of about 4cm per year.

► The exploits of the Apollo astronauts have been immortalised in films such as *Apollo 13* (left) and *First Man* (far right), to inspire future generations

Nick Spall is a freelance space writer. He's interviewed astronauts and experienced zero-G and parabolic flights

Elon Musk, Paul Allen and Jeff Bezos have all noted their own 'Apollo effect' calling.

Apollo was a world experience – 500 million watched the Moon landing in 1969, a fifth of the globe's population. Culturally, it can be argued that the 'can-do' attitude of NASA from the Apollo years is now respected on a worldwide scale.

The visceral and heroic nature of the human spaceflight adventure has become fascinating to young people in recent years, thanks to movies like *Apollo 13* (1995) and *First Man* (2018). Real space travellers, like the UK's Tim Peake and the reluctant hero Neil Armstrong himself, are new role models. Another key legacy of the Apollo Moon landings must be the deep philosophical consequence of mankind knowing that it achieved the extraordinary.

The common view of Apollo and the desire to 'choose to go to the Moon' is arguably at the core of the human spirit, with a common desire to explore and venture as far as possible from home – "because it's there," as Everest climber George Mallory put it. There are new worlds to explore beyond Earth orbit and Apollo's success confirmed that the dream of deep space travel is indeed achievable.

The Apollo message was highly emotional for many – Arthur C Clarke said at the launch of Apollo 11, "I cried for the first time in 20 years! ... This is the last day of the old world".

50th
1969 | 2019
APOLLO 11

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Exploring the Apollo landing sites

Sue Nelson discovers what the Apollo astronauts got up to while on the surface of the Moon

Fifty years ago, for the first time in history, human beings walked on the Moon. This 'giant leap' resulted from the audacious Apollo programme. NASA's series of lunar landings allowed 12 astronauts to stand on the Moon's grey powdery soil and to gaze, across space, at our own blue planet.

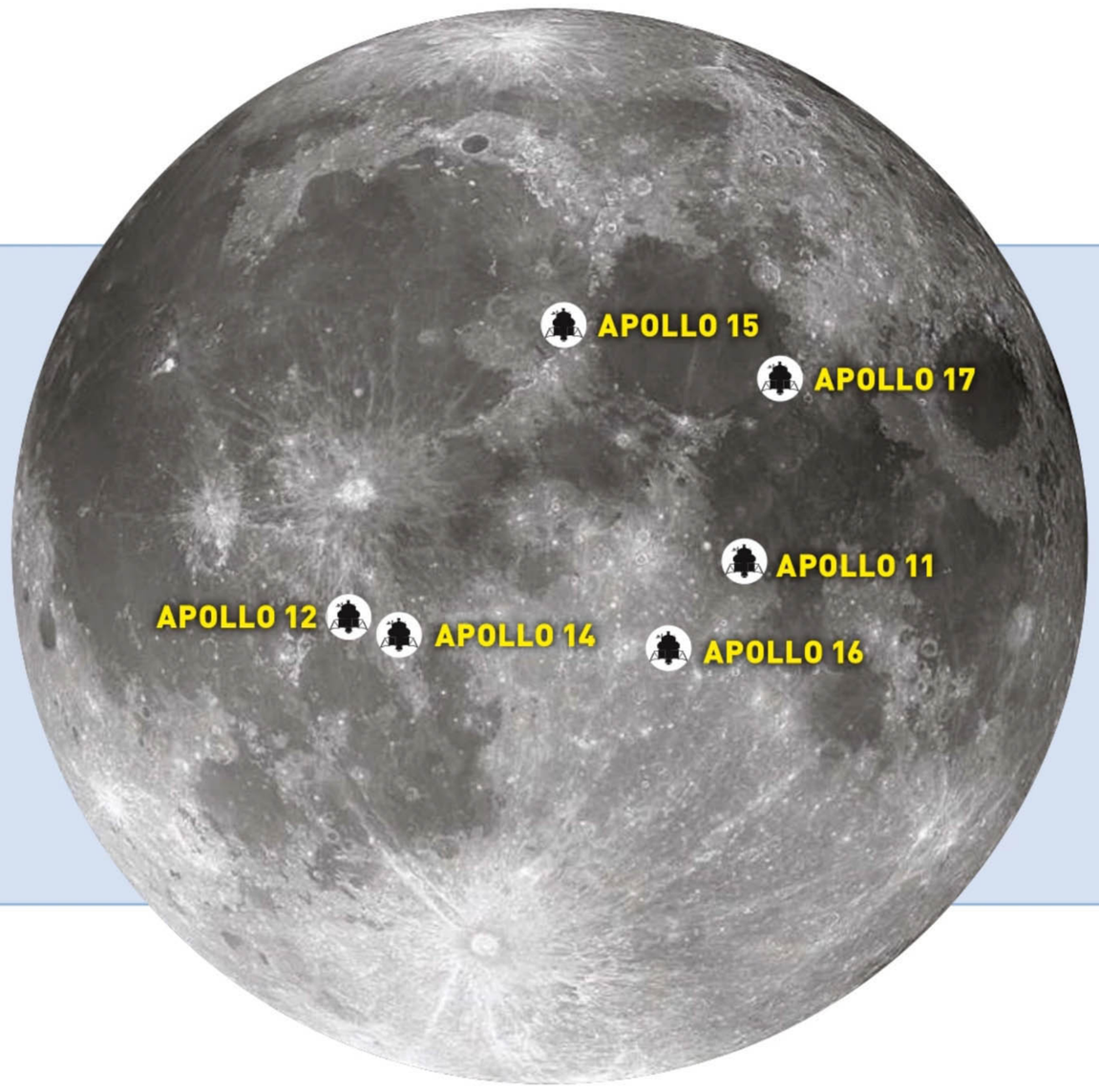
Between July 1969 and December 1972, six Apollo spacecraft landed in six different sites on the near side of the Moon. These sites are dotted across bright, mountainous highlands and the darker plains, or maria. Each site is geologically different and can be easily located using a telescope or binoculars from Earth. However, it wasn't until the Lunar Reconnaissance Orbiter launched in 2009 that we were able to make out the landers and footprints that the Apollo astronauts left behind.

During each of the successful missions a lunar module containing two men descended to the surface, leaving the third crew member to pilot the command module orbiting the Moon. The two moonwalkers would then undertake at least one EVA (extravehicular activity), during which they would set up a TV camera, carry out scientific experiments and collect geological samples.

Over the following pages is a guide to the astronauts' activites, highlights of what they did there, what they brought back and what they left behind. ▸

NASA

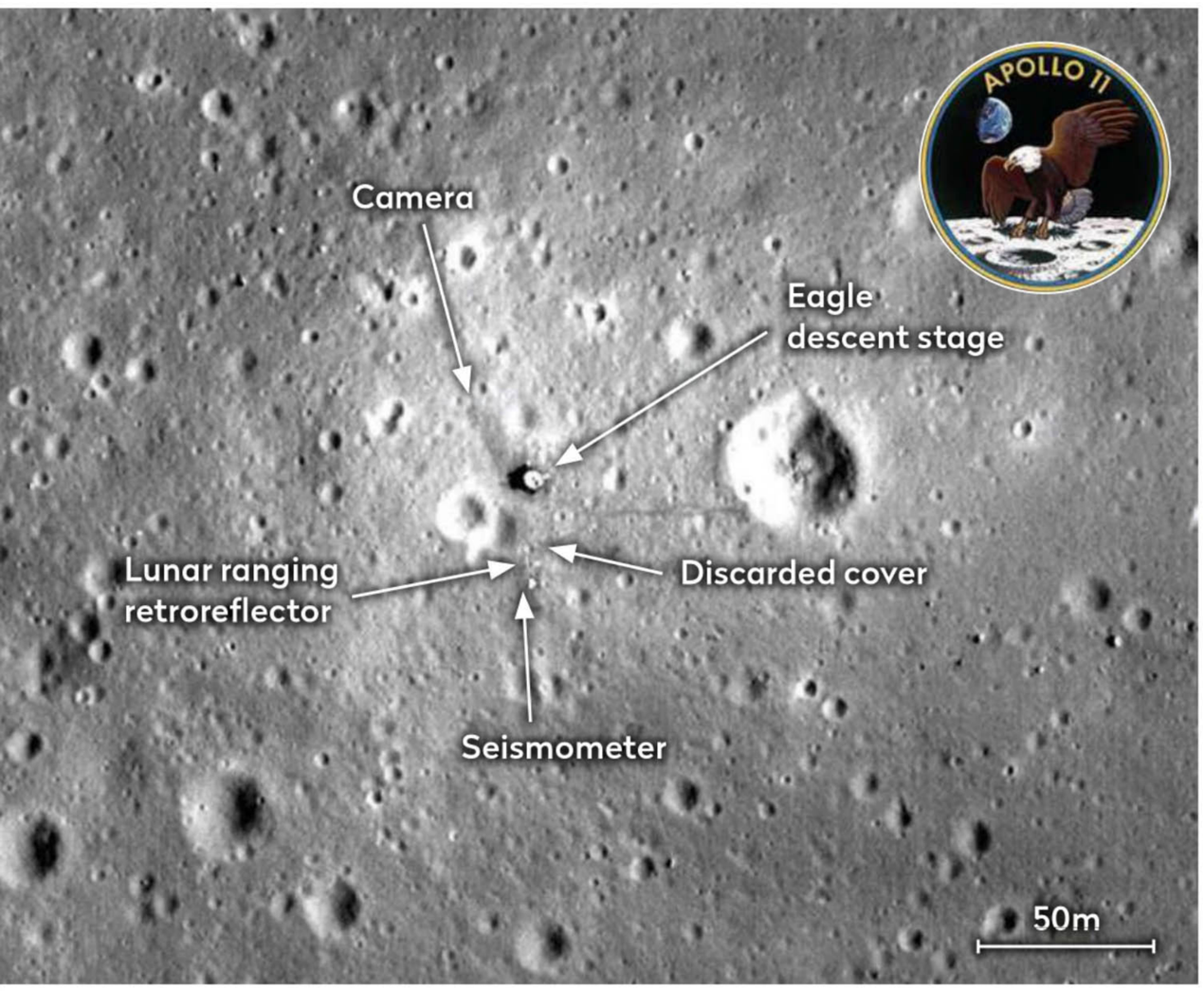
Gene Cernan test drives the lunar rover at the landing site of the Apollo 17 mission, the last one to visit the Moon



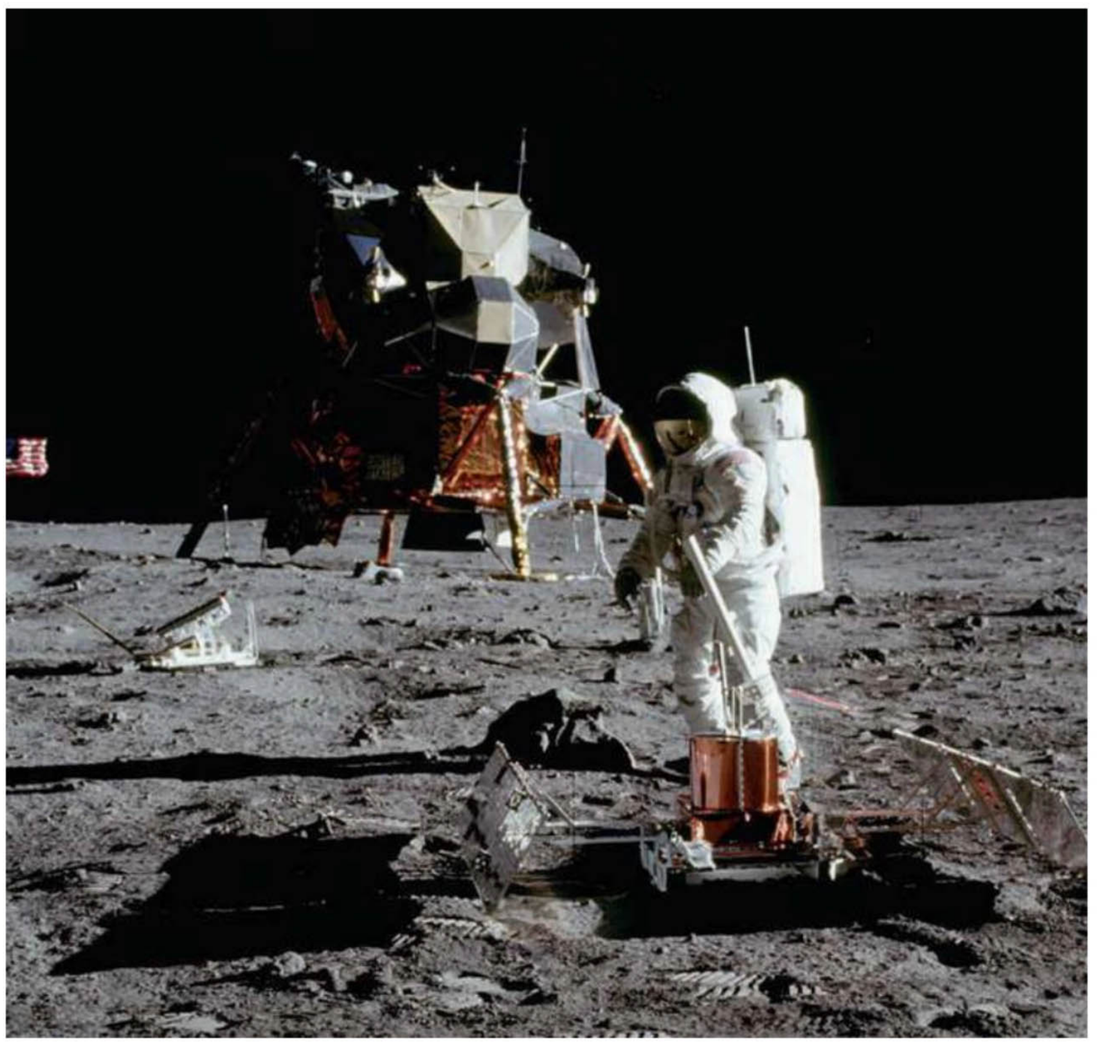
Where are the LANDING SITES?

To select where the Apollo missions would set down on the Moon, NASA shortlisted a series of potential landing areas near the lunar equator, where the Moon's faster rotation speed would make it easier for the ascent stages to take off. Using high resolution images from the Surveyor probes, the smoothest, crater-free locations for each final landing site were chosen. For the later, longer missions, more emphasis was put on choosing areas that were geologically interesting.

Apollo 11: Sea of Tranquillity



▲ Around 100 items were left behind at the Apollo 11 landing site



▲ Buzz Aldrin deploying the passive seismic experiment

NASA X 5, SCIENCE HISTORY IMAGES/ALAMY STOCK PHOTO, NASA GODDARD/ARIZONA STATE UNIVERSITY X 3, PETE LAWRENCE

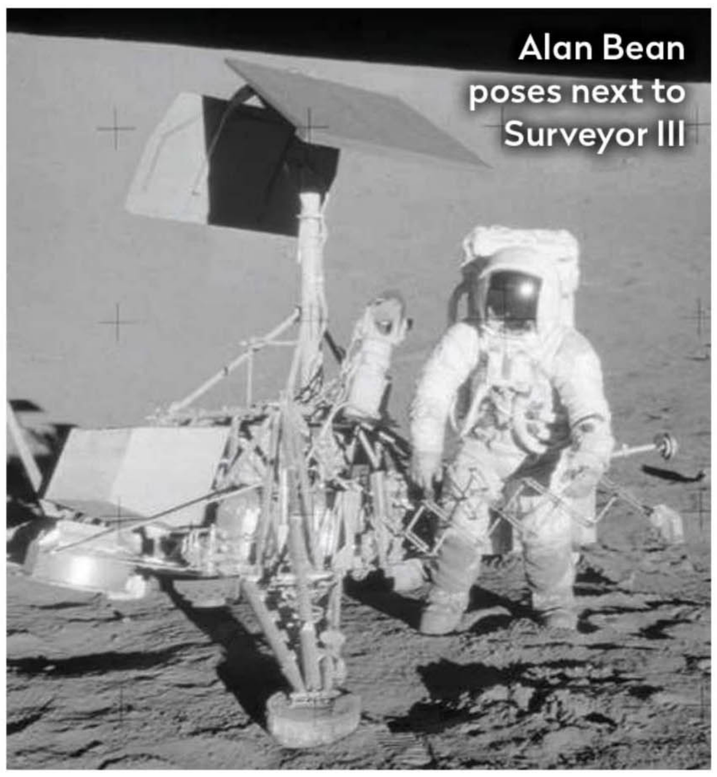
On 21 July 1969, Neil Armstrong became the first man to walk on the Moon. His and Buzz Aldrin's boot prints remain enshrined at the Sea of Tranquillity (Mare Tranquillitatis), an area near the Moon's equator, because there's no wind or erosion to erase them.

The landing site is near the distinctively large crater Theophilus, to the right and southwest of the Moon's centre. From here it's almost due north to the equator and the pin-sharp crater Moltke. Eagle touched down northwest of Moltke beneath three smaller craters, now named Aldrin, Collins and Armstrong after Apollo 11's crew.

Once thought to be a lunar ocean, the site is a relatively flat area with few boulders or craters. The two astronauts spent a total of two hours and 32 minutes on the surface of the Moon, travelled 1km and collected 21.55kg of samples for lunar field geology. While they were there, they also deployed a passive seismic experiment package, a laser ranging retroreflector – to measure the distance between the Earth and the Moon – and a cosmic ray detector.

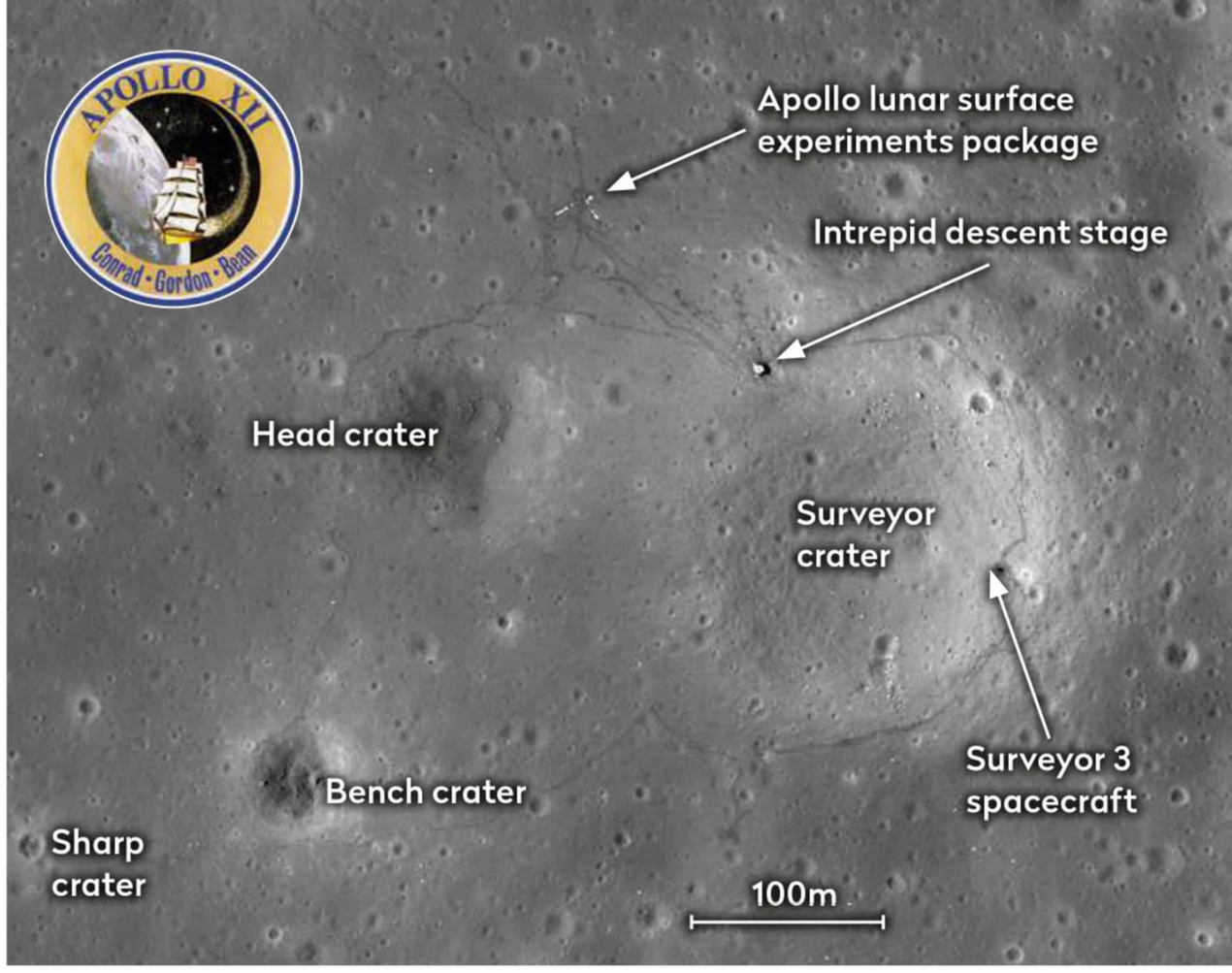
The mission left behind around 100 objects in the so-called 'toss zone' — from space boots and defecation collection devices to a TV camera and the American flag. The single biggest piece of lunar litter is the descent stage of the Eagle lunar lander. The smallest include a silicon disc containing microscopic messages from heads of state including the Queen, and an Apollo 1 mission patch in tribute to the three astronauts who died in 1967.

Apollo 12: Ocean of Storms


Alan Bean poses next to Surveyor III

Four months after Apollo 11, on 19 November 1969, Pete Conrad and Alan Bean also landed on an equatorial lunar plain. At more than 3,000km wide, the Ocean of Storms (Oceanus Procellarum) is thought to be an impact basin.

The area is southwest of Copernicus crater, the large, light grey crater within the largest dark region on the left-hand side of the Moon. It is close to Reinhold crater and southwest of Lansberg crater. The landing site is to its southeast, almost directly below Reinhold.



▲ **Apollo 12 was the first to deploy the the lunar experiments package**

The site was chosen because it contained NASA's Surveyor III, which landed 20 April 1967, and the mission proved Apollo 12's landing precision since it came to rest just 160m away.

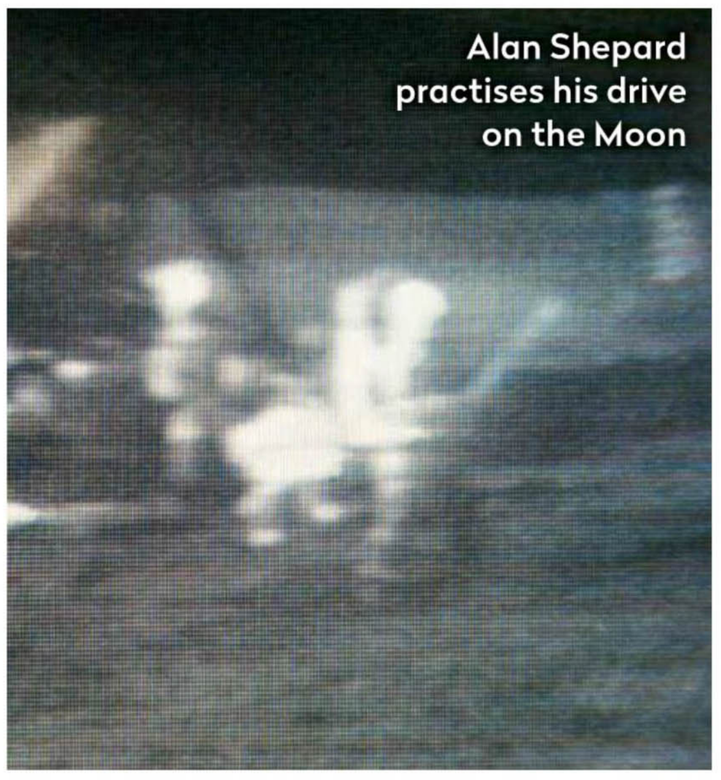
During the two EVAs undertaken by the Apollo 12 astronauts, totalling 7 hours 45 minutes, the astronauts deployed the first Apollo lunar surface experiments package (ALSEP) and also visited Surveyor III to examine its condition.

Apollo 12 returned with 34kg of lunar samples and brought back pieces of Surveyor for analysis. Like Apollo 11, they also left behind various tools and cameras, as well as earplugs and Bean's silver astronaut pin. Unfortunately, during the mission, Bean accidentally pointed the television camera at the Sun while mounting it on a tripod. This temporary loss of transmission produced a lifetime of conspiracy theories.

Apollo 14: Fra Mauro Highlands

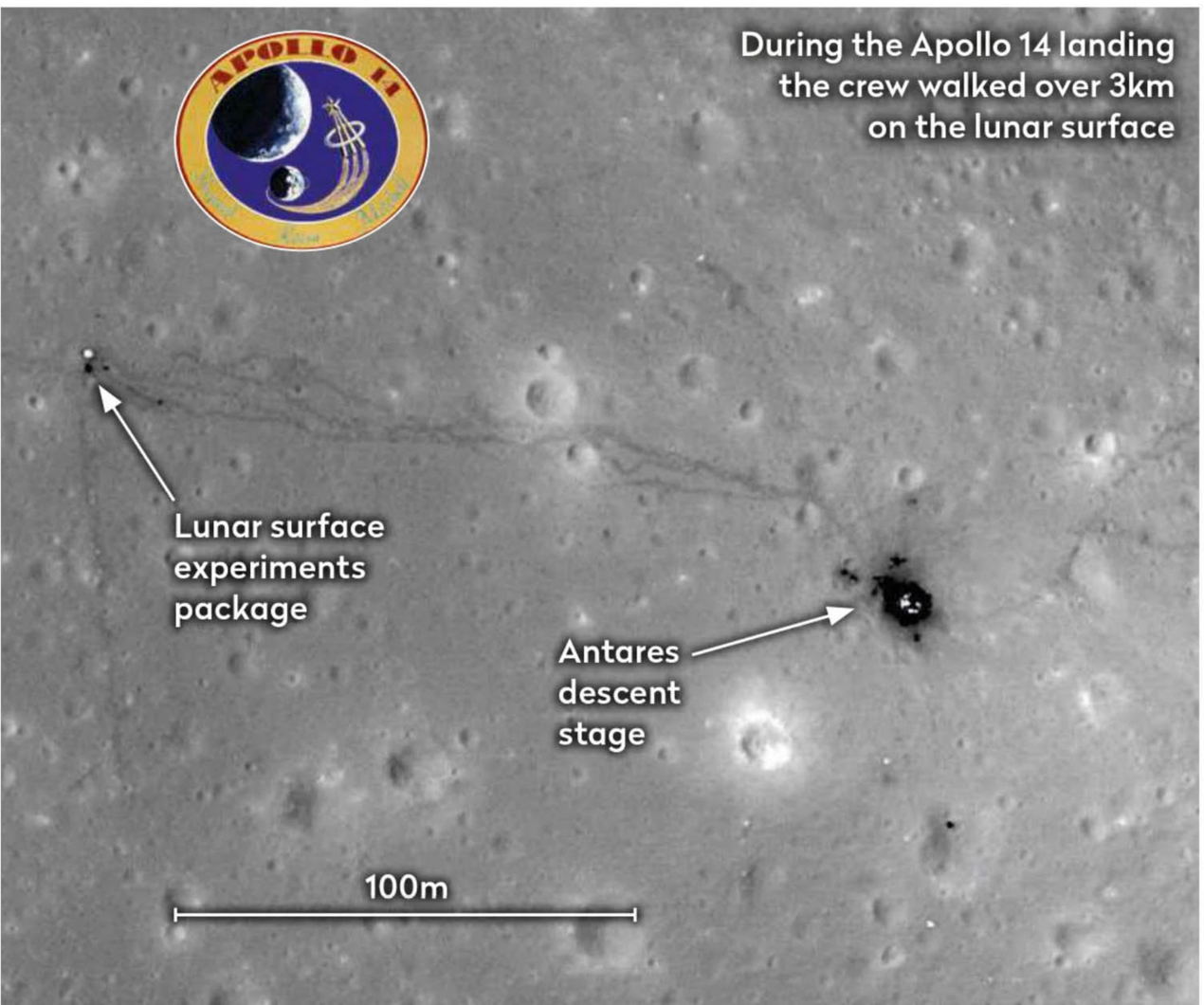
Fra Mauro is named after the 15th-Century Italian monk and map maker. It was originally Apollo 13's destination, before that mission developed its famous and understated 'problem', but it was a useful location since Apollo 12's seismometer had detected moonquakes that originated from the Far Mauro crater.

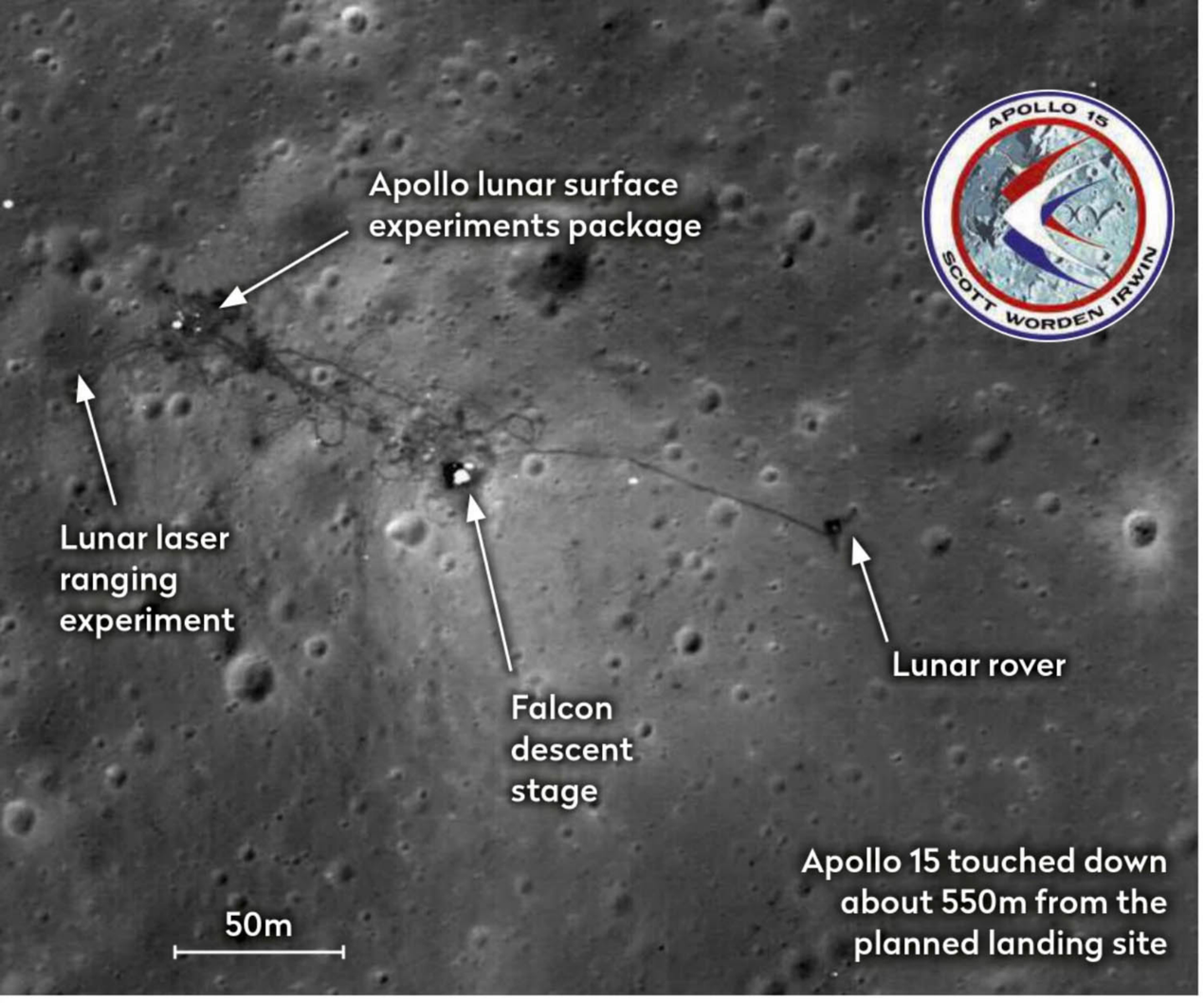
Like both previous Moon landings, the Apollo 14 site was also on the equator, just 177km east of where Apollo 12 landed. It lies to the right of that site and directly below Copernicus crater.


Alan Shepard practises his drive on the Moon

Alan Shepard and Edgar Mitchell began Apollo 14's two EVAs on 5 February 1971. They spent 9 hours 23 minutes on the surface, walked over 3km and collected 42kg of lunar soil and rocks. The mission's second EVA, to Cone crater, ended 15m from the rim, as it was on a slope and had left them 30 minutes behind schedule.

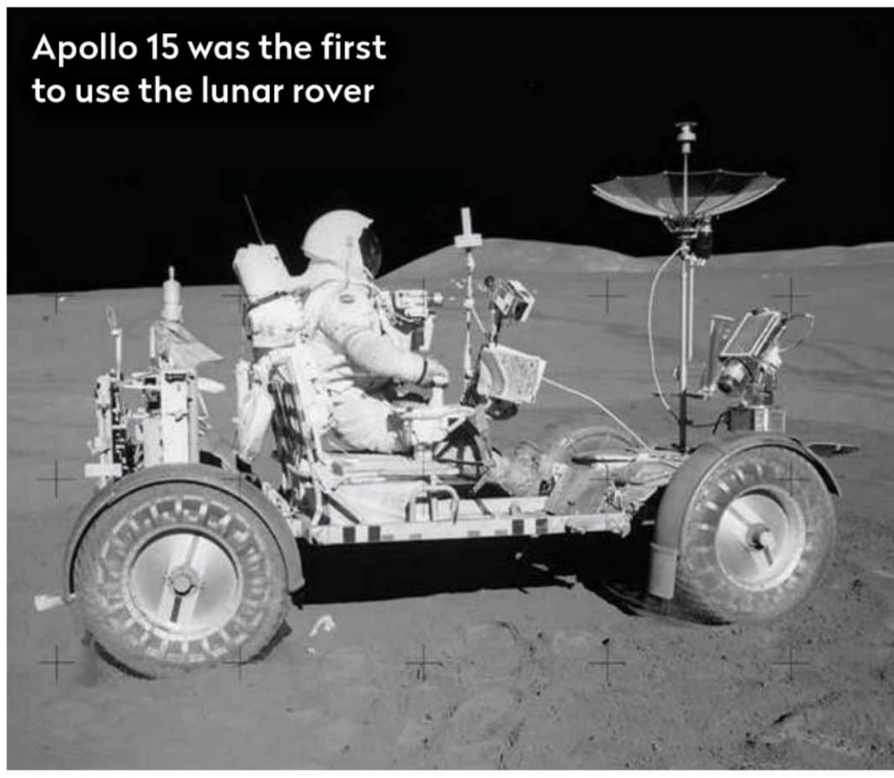
Mitchell returned with a camera, the only mission to do so, citing not enough time to remove its film. However, Commander Shepard found time for some sport before re-entering the lunar module to return home. He attached a golf club face to a sample collector handle, hitting one ball into a crater and a second into the darkness. So, apart from the usual detritus, Apollo 14 left two golf balls on the Moon. ►





Apollo 15: Apennine Mountains

Apollo 15 was the first mission to carry a lunar rover vehicle, and the first not to set down on the equator. It landed on the right 'eye' of the man in the Moon, in the Sea of Showers (Mare Imbrium), in the central part of the lunar northern hemisphere. The site is southeast of the Archimedes crater at the foot of the Apennine mountains (Montes Apenninus).



Dave Scott and Jim Irwin took their first lunar steps on 30 July 1972. They were 550m from the planned landing point because a loose plug had required readjusting before the descent.

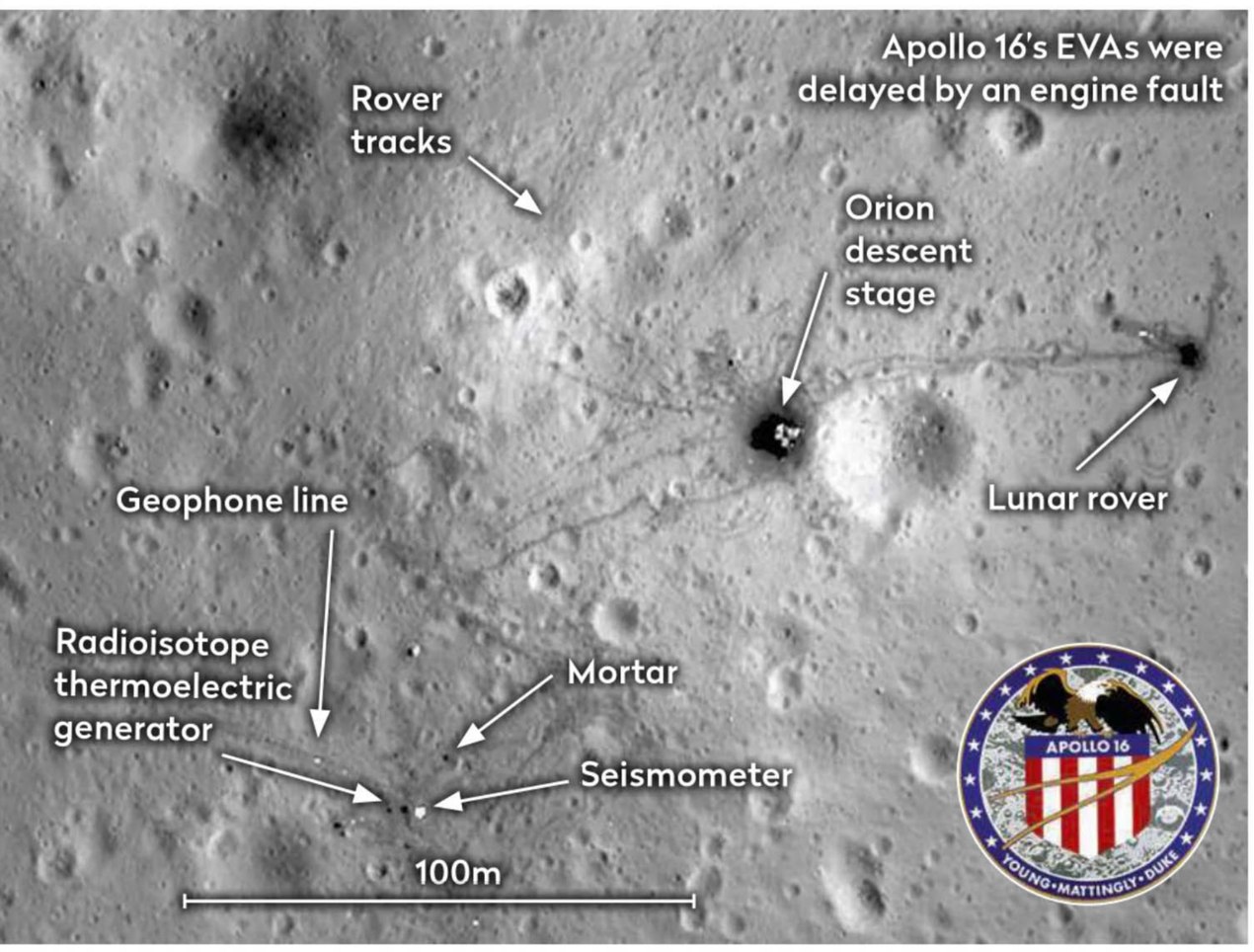
Their four-wheeled, electric-powered rover could reach a speed of 16km/h. This extended the astronauts' range for exploration and capacity for samples. As a result, they travelled 23km and gathered 370 samples weighing 77kg from both the site and the volcanic Hadley Rille nearby – a rille being the name for the narrow fissures on the lunar surface.

The crew were on the surface for 18 hours 35 minutes during three EVAs. Like the previous two missions, they deployed an ALSEP (Apollo lunar surface experiments package), but deploying the heat flow experiment, which required drilling a 2m hole for the sensor, proved too difficult. One drill core, however, did penetrate to 2.4m to obtain samples.

Objects left on the Moon included a Bible, a 'fallen astronaut' memorial, some $20 bills, the lunar buggy, a feather and a geological hammer. The latter two items were used to prove that objects released together in a vacuum fall at the same rate, regardless of mass – when Scott dropped the feather and hammer simultaneously, they landed on the ground at the same time.

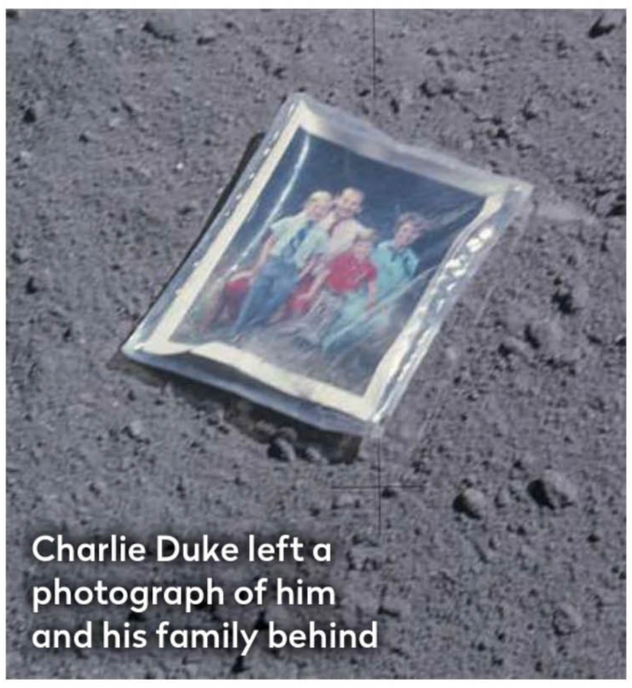
NASA X 8, NASA GODDARD/ARIZONA STATE UNIVERSITY X 3

Apollo 16: Descartes Crater



Apollo 16 was the first landing south of the equator in the central lunar highlands. Its aim was to study the unexplored terrain of the hilly Descartes formation (named after the French philosopher) and the smooth Cayley plains. The mission landed near Theophilus crater, due west of it, almost midway between the Theophilus and Ptolemaeus craters. A malfunction in an engine back-up unit delayed the landing by several hours, so moonwalkers John Young and Charlie Duke slept in a hammock inside the lunar module before beginning the first of three EVAs, carried out across two days, on 21 April 1972.

The astronauts eventually covered 27km during 20 hours 14 minutes on the surface. Like Apollo 15, the mission carried a rover. Apollo 16 also carried an ALSEP but due to a loose cable, the heat flow experiment didn't work. The mission returned with 731 samples of rocks and soil weighing 96kg. These samples revealed that the two areas were not volcanic, as had been expected, but were in fact made up of debris from impact events.

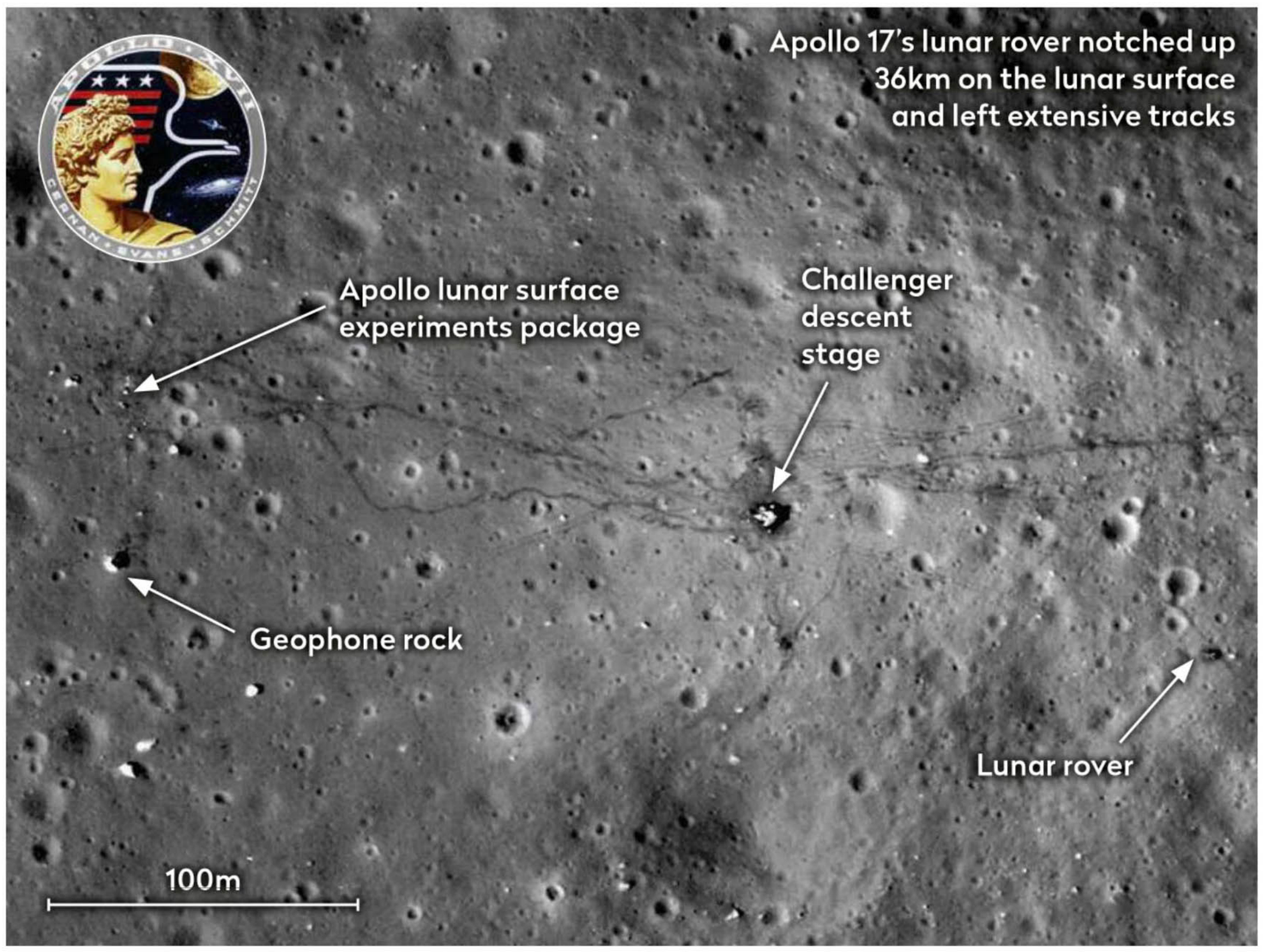

Charlie Duke left a photograph of him and his family behind

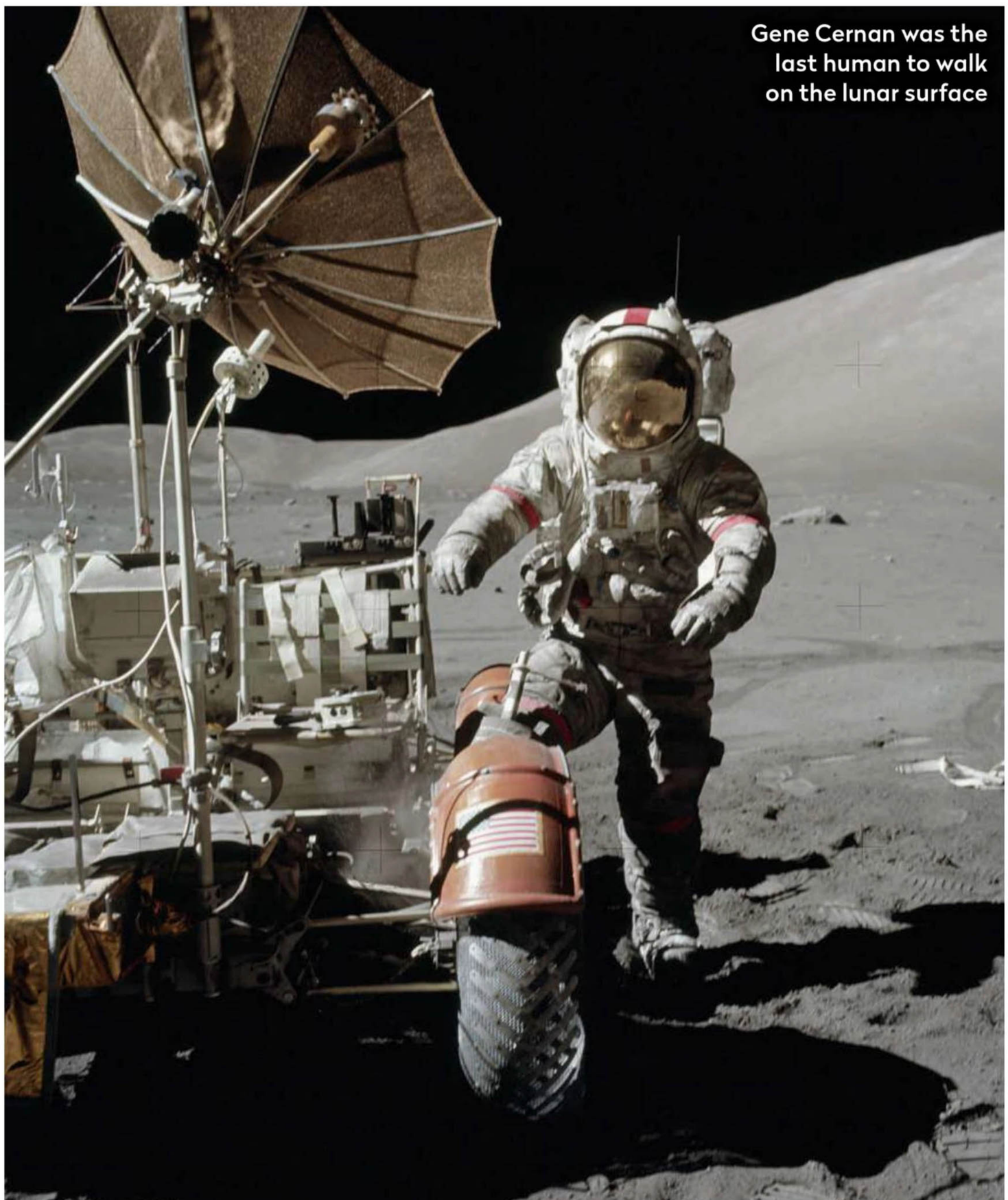
Among the usual litter of batteries, instruments and defecation bags left behind on the Moon were a hammock, a picture of Charlie Duke's family, and a gold-plated telescope that the astronauts had used to take pictures of Earth's outer atmosphere (the geocorona).

Apollo 17: Taurus-Littrow

The sixth and final Apollo mission touched down in the Taurus-Littrow valley in the northern lunar hemisphere. It was close to Apollo 15's landing site, but further east across the dark Serenity (Serenitatis) basin towards the distinctive elongated oval of Posidonius crater. There are three smaller craters beneath it and Apollo 17's Gene Cernan and Harrison Schmitt explored between the second and third of these, Littrow and Vitruvius.

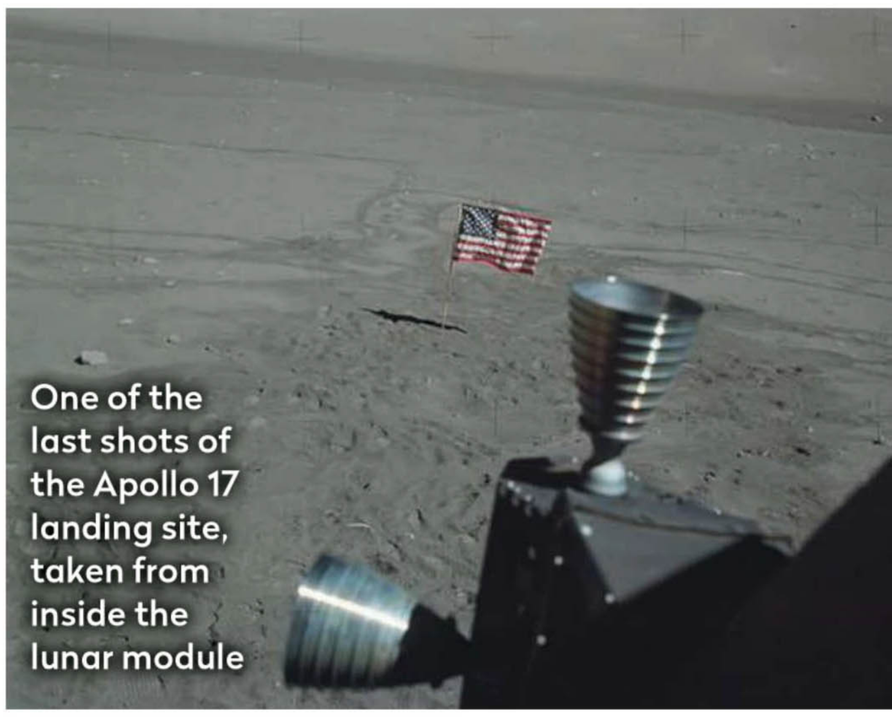
Schmitt, a geologist, was the Apollo programme's only scientist, and the site provided a chance to sample both young rocks from the valley floor and older rock samples from the lunar highlands. The astronauts spent 22 hours performing three EVAs with the lunar rover notching up 36km – the furthest point being 7,370m from the spacecraft. Their 741 samples weighed 111kg and included a deep drill core that went 3m below the surface.




Gene Cernan was the last human to walk on the lunar surface

Apollo 17 also left behind experiments, soap and even nail clippers. The rover was abandoned without a right rear fender because Cernan had damaged it before heading to deploy the ALSEP. However, Cernan's final footprint on the lunar surface, the most poignant artefact, is both ethereal and permanent.

Sue Nelson is an award-winning science journalist and the author of *Wally Funk's Race For Space.*


One of the last shots of the Apollo 17 landing site, taken from inside the lunar module

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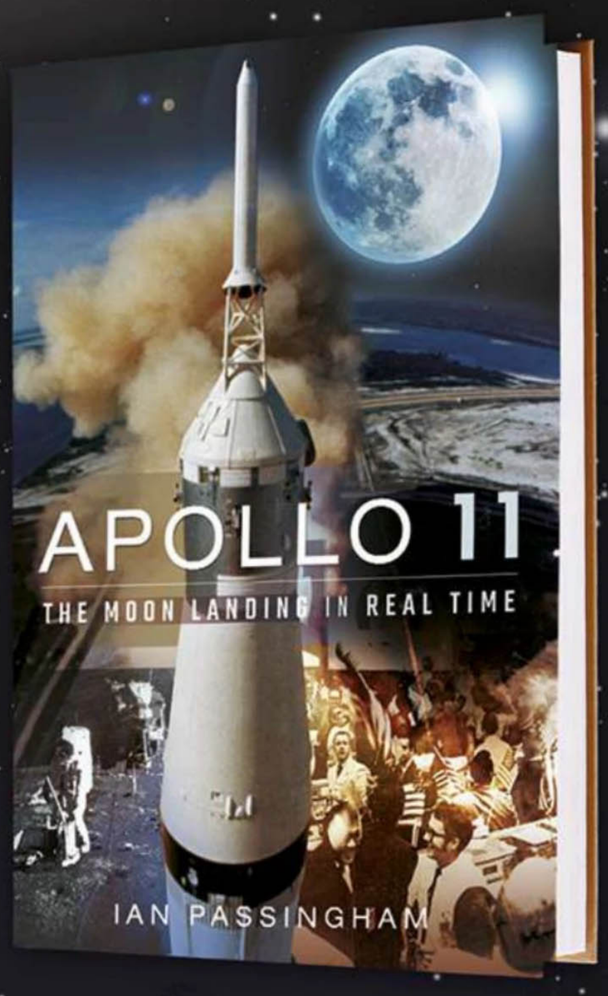

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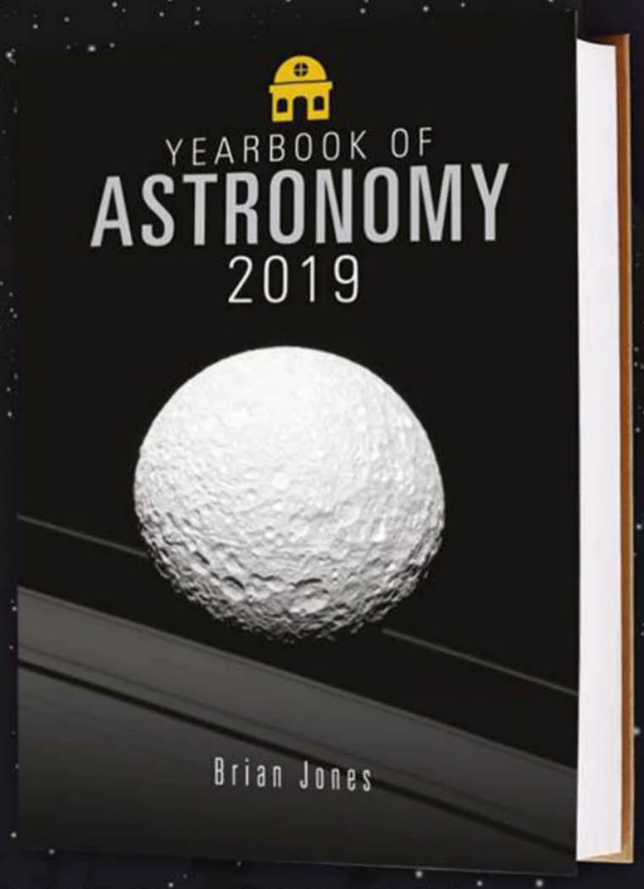

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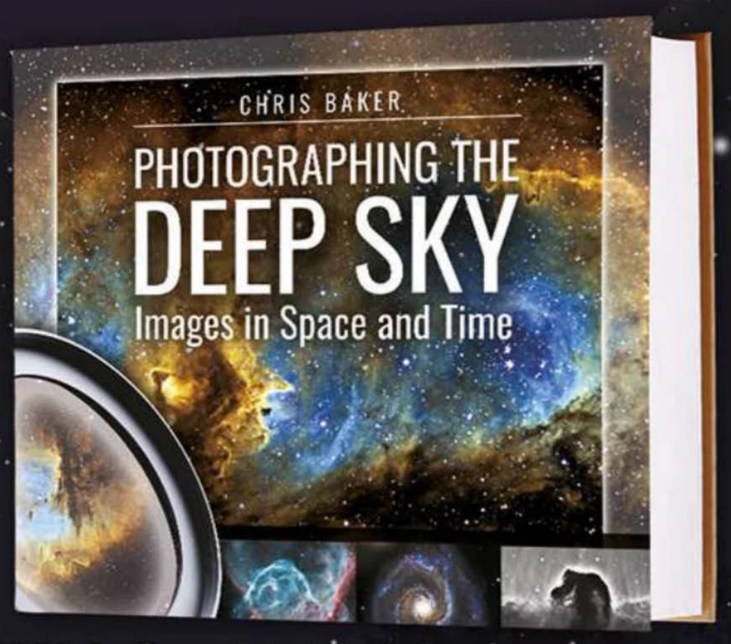

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BBC Sky at Night MAGAZINE

The Sky Guide

JULY 2019

16-PAGE CENTRE PULLOUT

A LUNAR ECLIPSE

On 16 July a large portion of the Moon's disc will be under Earth's shadow

NOCTILUCENT CLOUDS

The high-altitude cloud season continues

YIN YANG MOON

Why has Iapetus got a permanent dark side?

PETE LAWRENCE

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* monthly on BBC Four

Stephen Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 54

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Also on view...

- Perseid meteor shower activity rises
- Dwarf planet Pluto reaches opposition
- Getting to know Iapetus, Saturn's walnut-shaped moon

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky, sign up to our newsletter: **www.skyatnightmagazine.com/iframe/newsletter-signup**

JULY HIGHLIGHTS

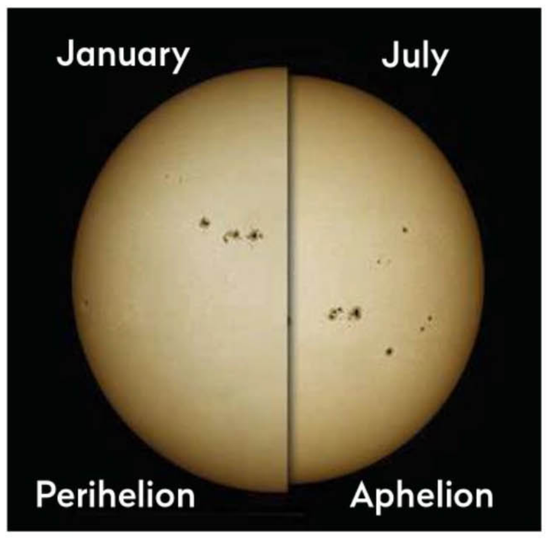
Your guide to the night sky this month

◀ All month

Noctilucent cloud season continues throughout July. If there, NLCs are typically seen 90–120 minutes after sunset low above the northwest horizon, or a similar time before sunrise low above the northeast horizon.

Thursday ▶

4 Earth reaches aphelion, the farthest point in its orbit to the Sun. Its distance will be 152,105,130km. For solar observers this marks the time when the Sun's apparent diameter reaches its minimum value.



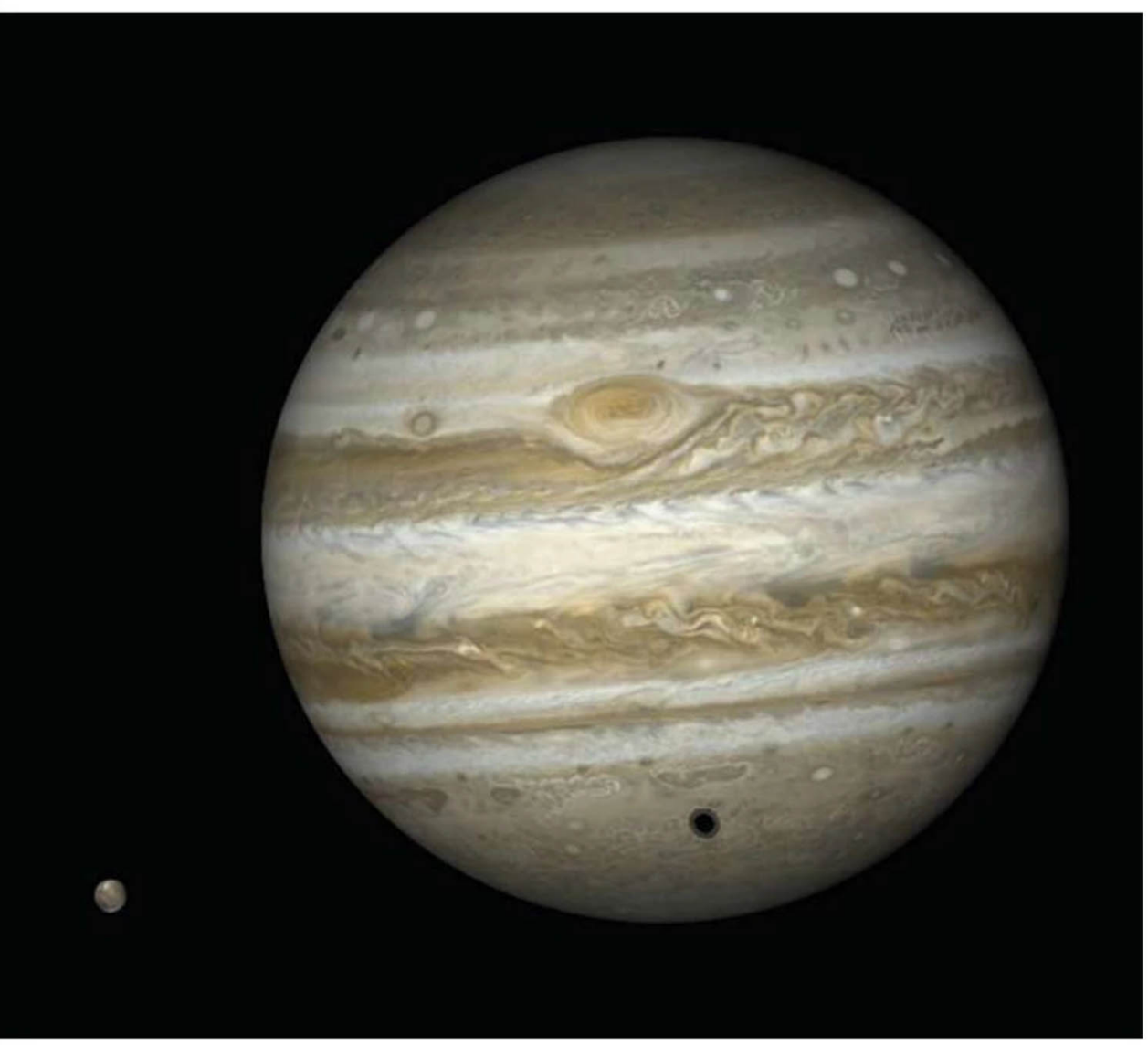
Friday

5 The opposition effect on Saturn should start to become visible. This effect causes the planet's rings to slowly brighten towards opposition.

Tuesday

9 Saturn reaches opposition.

Our Moonwatch target, the impressive Montes Caucasus, is visible this evening (see page 52



Wednesday

10 The shadow of Jupiter's giant moon, Ganymede, will appear on the planet's central meridian (an imaginary line from north to south) at 21:30 BST (20:30 UT).

Saturday

13 This evening's 90%-lit waxing gibbous Moon lies less than 2° northeast of Jupiter.

The clair obscure effect Cassini's Moon Maiden is visible around 23:00 BST (22:00 UT).

Tuesday ▶

23 Today traditionally marks the start of the annual Perseid meteor shower. This year a bright Moon interferes with peak activity around 12 and 13 August. However, there is plenty of opportunity to see early Perseids in the run up to that.

Friday

26 Peak of the weak North Delta Aquarid annual meteor shower. The Zenithal Hourly Rate (ZHR) typically reaches an average of 3.5 meteors per hour.

Saturday ▶

27 The early morning waning crescent Moon is currently showing a favourable libration (its small rocking and rolling motion) and phase for viewing features in the lunar northwest such as the 130km-diameter, crater Pythagoras.

Sunday

28 This evening Jupiter appears to have another moon in the shape of mag. +10.3 TYC 6230-1737-1. The star can be seen just to the north of the planet.

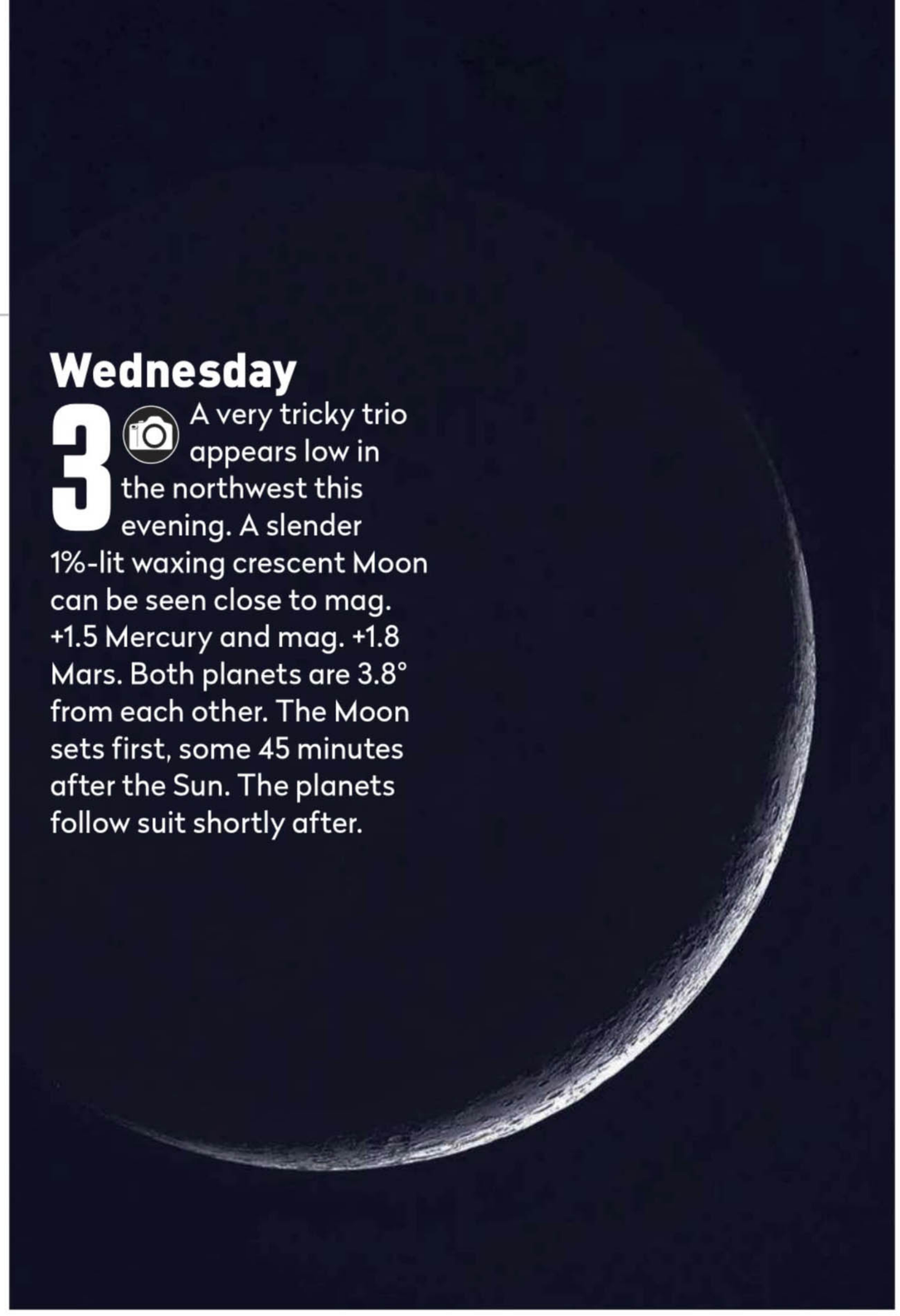
PETE LAWRENCE X 8

Tuesday

2 Minor planet 18 Melpomene reaches opposition at mag. +9.2 in the constellation of Scutum.

Wednesday

3 A very tricky trio appears low in the northwest this evening. A slender 1%-lit waxing crescent Moon can be seen close to mag. +1.5 Mercury and mag. +1.8 Mars. Both planets are 3.8° from each other. The Moon sets first, some 45 minutes after the Sun. The planets follow suit shortly after.



Sunday

14 Dwarf planet Pluto reaches opposition.

Around midnight BST (23:00 UT) Jupiter's outermost Galilean moon, Callisto, can be seen south of Jupiter's disc.

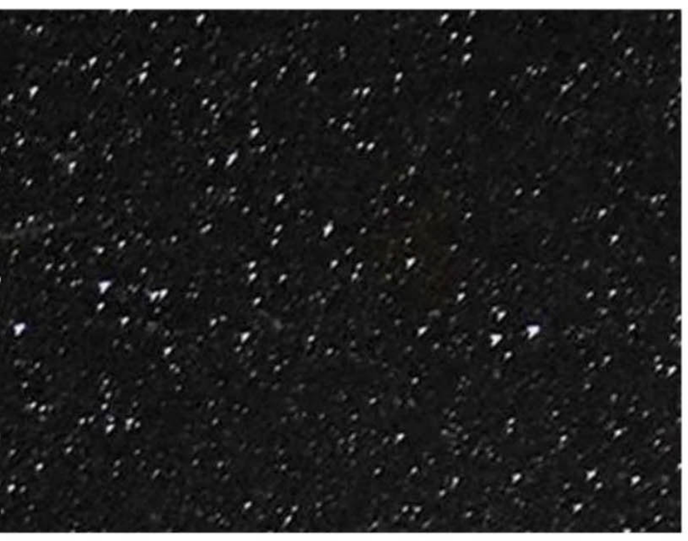
Monday

15 Tonight and tomorrow night, the full Moon lies close to mag. +0.5 Saturn.

Tuesday

16 A partial lunar eclipse occurs this evening – see page 46 for details.

View Saturn in the early hours to see a mag. +10.8 star called TYC 6295-1296-1, which looks like an extra moon, near Saturn's northwest limb.



Wednesday ▶

24 With the Moon now out of the way, this is a good time to attempt this month's Deep Sky Tour which can be found on page 56. This month we're looking at objects around the diamond-shaped constellation of Scutum.

Monday

29 Tonight sees the peak of the annual Southern Delta Aquariid meteor shower, which typically reaches a ZHR of 18 meteors per hour.

Family stargazing

There's a good opportunity to spot a partial lunar eclipse on 16 July. The event is underway at moonrise around 21:15 BST (20:15 UT). Visibility may be difficult initially as low altitude will make it hard to pick out. This adds an element of anticipation and a game can be made as to who sees the Moon first. It'll be rising in the southeast so a compass or smartphone's compass app is a good idea to get an idea of where to look. Once seen, encourage sketches to record how much of the Moon is covered by Earth's shadow at set times – say every 15 minutes.

www.bbc.co.uk/cbeebies/shows/stargazing

NEED TO KNOW

The terms and symbols used in The Sky Guide

Universal time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT.

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'.

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_Lessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope.

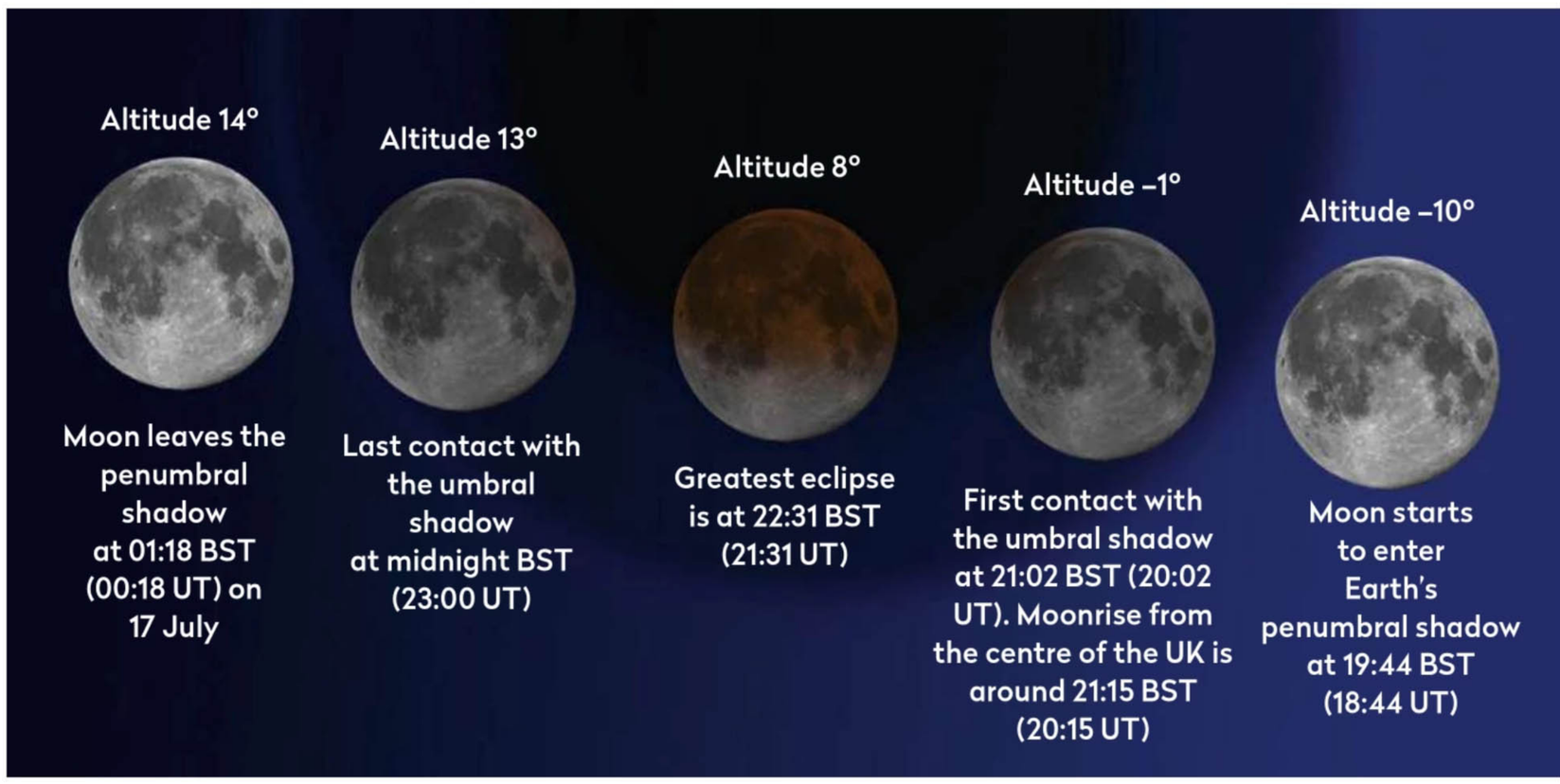
THE BIG THREE

The three top sights to observe or image this month

DON'T MISS

Partial LUNAR ECLIPSE

BEST TIME TO SEE: From moonrise on 16 July until midnight BST (23:00 UT)



▲ **The Moon's path relative to the Earth's shadow in space on 16 July. It will be 65% eclipsed**

We're being spoilt for lunar eclipses in 2019. After a spectacular total lunar eclipse in the early hours of 21 January, we're set for a significant partial lunar eclipse on 16 July. However, don't get complacent because this will be it for a while. After the July partial eclipse, the next lunar eclipse potentially visible from the UK occurs on 19 November 2021 and even then, this may only just be visible as the Moon sets at daybreak. The next total eclipse visible from the UK occurs in the early morning on 16 May 2022, but timing isn't favourable with the Moon setting while totally eclipsed. The next well placed total lunar eclipse visible from start to finish from the UK won't occur until 21 December 2029.

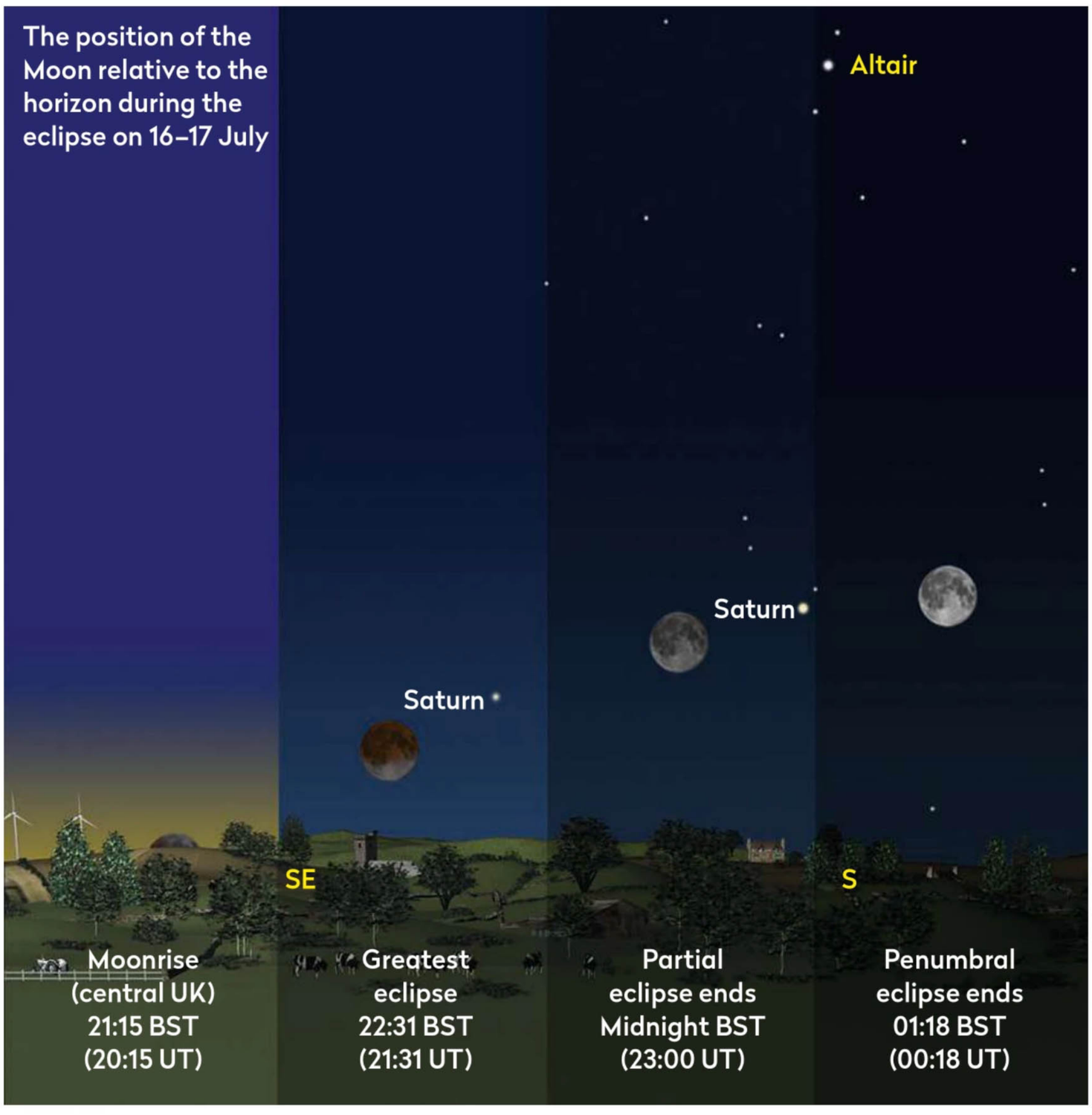
This month's partial eclipse begins before the Moon has risen on 16 July. The Moon makes its appearance above the southeast horizon around 21:15 BST (20:15 UT), but this time varies slightly depending on your location. Timing favours the southeast and those living in this part of the country may get to see the Moon rise just before Earth's dark umbral shadow begins to cross its disc.

The visibility of even a full Moon may be very compromised when low down. This depends on the clarity of the atmosphere at moonrise. Often the Moon only becomes visible when it has climbed a degree or two above the horizon.

As visibility improves with altitude it'll be evident that it's the Moon's northwest portion being covered by Earth's dark umbral shadow. This eclipse has a magnitude of 0.65, which means that at the point of greatest eclipse (22:31 BST, 21:31 UT) the widest part of the umbral shadow stretches across 65% of the Moon's diameter. As luck would have it at this size of coverage, the Moon will look like it's exhibiting a regular crescent phase. However, for those familiar with the appearance and monthly phases of the Moon, its appearance will feel a little odd.

The rise time of the full Moon occurs as the sun is setting in the opposite direction. Consequently, it will take a while for the sky to properly darken. As it does and the eclipse progresses, so visibility will improve.

The umbral shadow leaves the Moon's disc at midnight BST (23:00 UT) as the Moon is approaching its most southerly position in the sky, and consequently its highest altitude above the horizon. The planet Saturn can be seen around 8° west of the Moon, with brilliant Jupiter around 30° to the west of Saturn.



ALL PICTURES: PETE LAWRENCE

Summer METEORS

BEST TIME TO SEE: From 23 July to mid-August

The period from the third week of July until the end of August is an excellent time to look for meteors. The reason is mostly down to the Perseid meteor shower reaching its peak around 13 August. This event reliably produces good meteor rates at a time when it's not too chilly outside.

However, not every year is ideal. For years when the Moon is in the sky around the peak, the number of meteors seen visually will fall. The reduction is quite dramatic with typically only the brightest trails being visible. Cameras are also affected but not as severely. As long as your exposure doesn't allow the sky to oversaturate to white, any trails recorded should still be recoverable using a graphics editor to tweak the image's levels.

The Moon is full during the morning of 15 August but also quite low in the sky. On the morning of 11 August, the 81%-lit waxing gibbous Moon sets around 01:30 BST (00:30 UT), providing a couple of dark hours to look out for Perseids. On the morning of 12 August the now 88%-lit waxing crescent Moon sets around 02:20 BST (01:20 UT) providing a window of around 70 minutes. On 13 August, the 94%-lit waxing gibbous Moon sets around 03:15 BST (02:15 UT), just before the onset of serious twilight.

The Perseid maximum is expected to occur between 03:00 BST (02:00 UT) and 16:00 BST (15:00 UT) on 13 August. This year therefore favours the run up to maximum which starts on 23 July when Perseid rates are very low. However, in addition to the Perseids, there are a lot of other less active showers in operation which means that the period of darkness from the third week of July into the first week of August is an ideal time to look out for summer meteors.

▲ From late July the Perseid meteor radiant moves from Cassiopeia to Camelopardalis

Up in the noctilucent clouds

BEST TIME TO SEE: All month and into the start of August

NLCs may first appear low in the northwest 90–120 minutes after sunset

At the time of writing we have no idea what the 2019 noctilucent cloud (NLC) season has delivered. Certainly the 2018 season was rather good with many impressive displays. Unfortunately, a good season one year is no indication that subsequent years will follow suit. The only way to tell is to go out and have a look.

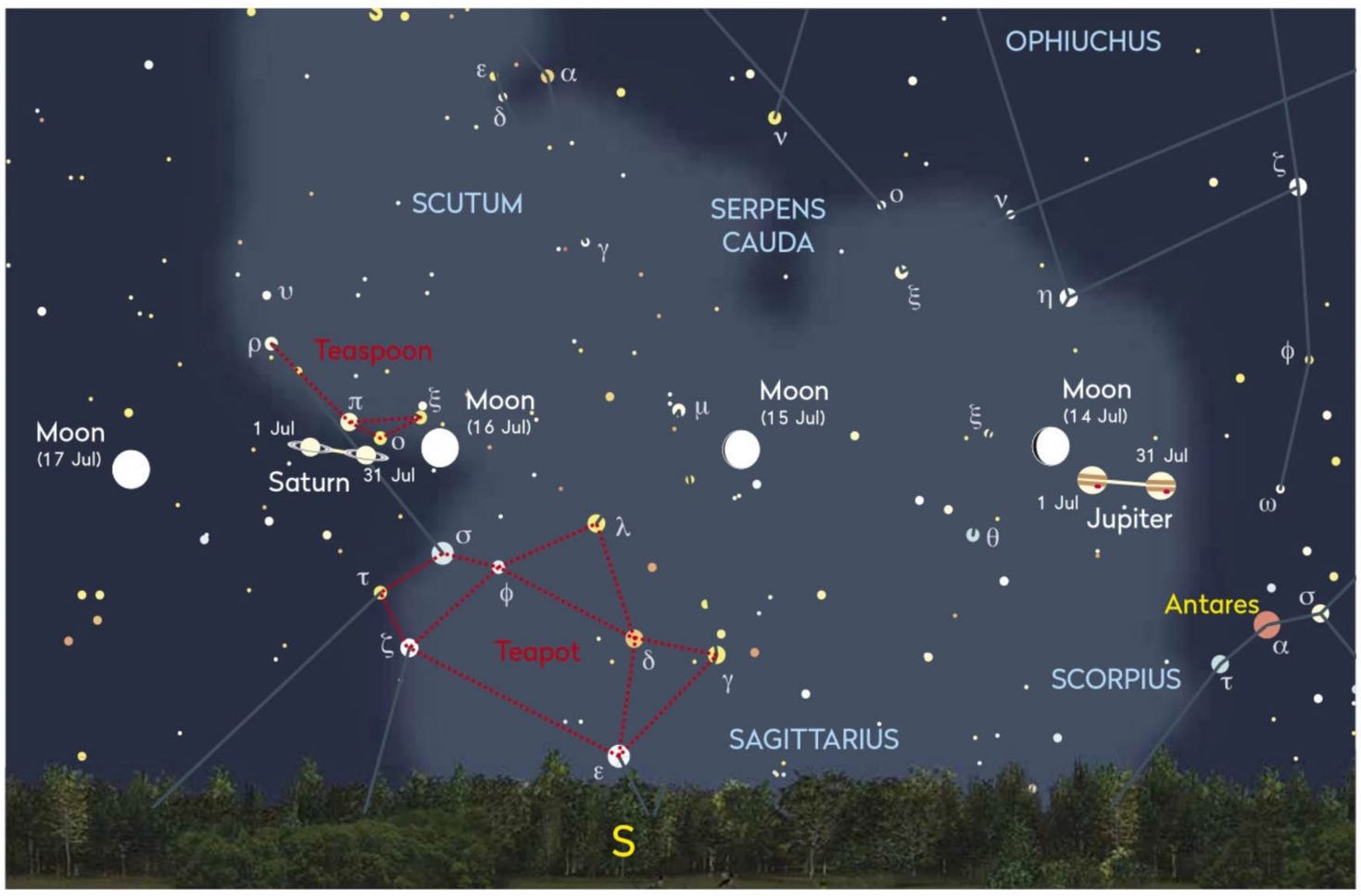
NLCs are the highest clouds on Earth occurring within a narrow layer 82km up in the mesosphere. At this height they are still able to catch the Sun's rays despite it being below the horizon for us on the ground. Reflecting sunlight, NLCs appear to shine during the hours of darkness; the name noctilucent means 'night shining'.

Timing is important because to see NLCs at all, the sky has to achieve a certain level of darkness. This occurs when the Sun has dipped 6° below the horizon. Reflectance generally continues to an altitude of –16°.

The ideal time to look for NLCs is 90–120 minutes after sunset when they may appear low above the northwest horizon, or a similar time before sunrise when they may appear low above the northeast horizon. Really extensive displays can sometimes be seen throughout the course of an entire night, tracking with the Sun as it moves below the horizon.

THE PLANETS

Our celestial neighbourhood in July



▲ **Saturn is visible below the Teaspoon asterism in the constellation of Sagittarius**

▲ **July is a good month for viewing Saturn, the planet reaching opposition on 9 July**

PETE LAWRENCE X 3

PICK OF THE MONTH

Saturn

Best time to see:
9 July, 01:15 BST (00:15 UT)
Altitude: 15°
Location: Sagittarius
Direction: South
Features: rings, atmospheric banding, storms, moons
Recommended equipment:
A 75mm or larger telescope

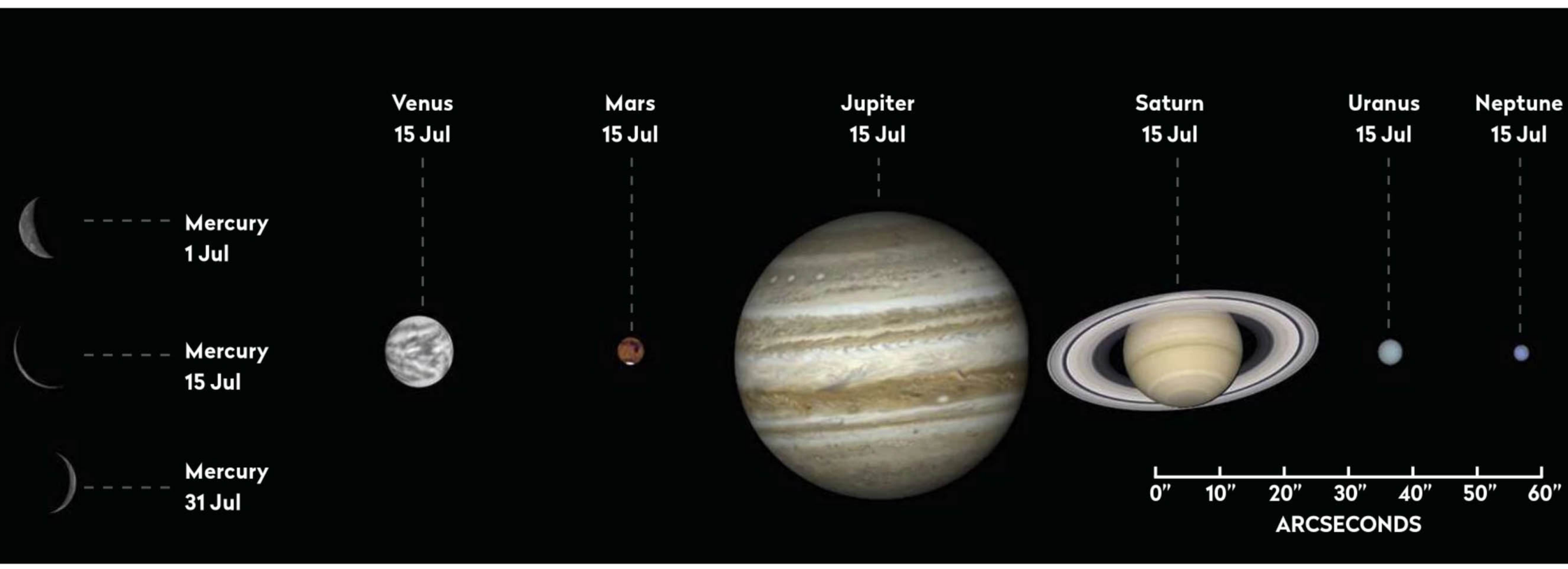
Saturn is at opposition on 9 July. In the days running up to opposition it's possible to see the planet's rings brighten. After opposition they then fade back to normal brightness. This phenomenon is known as the Opposition Effect. The planet is currently visible south of the Teaspoon asterism in Sagittarius, which itself is located northeast of the larger and more distinctive Teapot asterism, also in Sagittarius. Saturn shines like a yellowish mag. +0.5 star all month and attains a maximum altitude, due south, of 15° as seen from the centre of the UK. Thankfully, the planet has now bottomed out on its slow drift south against the stars and is starting to ascend northwards once more. It'll take a few years for the effect to make much of a difference, but it's still a positive milestone for those of us viewing Saturn from the UK. The full Moon lies close to Saturn on the nights of 15 and 16 July. Through a telescope, the planet's northern pole is currently tilted over towards Earth by 24.5°.

Although Saturn's rings are the obvious attraction when you view the planet through a scope, its brighter moons are also interesting, even at low altitude. The largest moon Titan is bright and moves far enough from the planet to be seen through binoculars. Then there's the odd 'yin-yang' moon Iapetus. We now know from probes that it has a bright and a dark hemisphere. Being tidally locked to the planet, we get to see its bright side when west of Saturn and dim side when to the east. The change in magnitude of Iapetus is from mag. +10.2 to mag. +11.9. It takes 79.3 days to complete an orbit around Saturn. The next western elongation occurs mid-month with the following eastern elongation occurring on 22 August.

▶ **Turn to page 55 for more information**

The planets in July

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope



Mercury

Best time to see: 31 July, 45 minutes before sunrise
Altitude: 1° (extremely low)
Location: Gemini
Direction: East-northeast

Mercury is an evening object at the start of July, but not well placed for viewing as it's south of the ecliptic. This means it sets soon after the Sun. It reaches inferior conjunction on 21 July when it lines up with the Sun on the earthward side of its orbit. It won't be easy to see when it re-emerges in the morning sky. Your best chance is on 31 July when it's 4° south of a 1%-lit waning crescent Moon.

Venus

Best time to see: 1 July, 30 minutes before sunrise
Altitude: 2° (very low)
Location: Taurus
Direction: Northeast

Venus is disappearing from view thanks to its shrinking separation from the Sun. Mag. –3.8 Venus rises 50 minutes before the Sun on 1 July when it's seen with a 3%-waning crescent Moon 9.5° to the southwest – that's to the right of Venus as seen from the UK. On 31 July an even thinner 1%-waning crescent Moon appears bereft of its planetary companion as Venus moves too close to the Sun to be seen. If you can get a view of Venus through a scope at the start of July, its disc is a rather small 9 arcseconds across.

Mars

Best time to see: 1 July, shortly after sunset
Altitude: 1° (very low)
Location: Cancer
Direction: Northwest

Mag. +1.8 Mars may just be seen above a flat northwest horizon just after sunset at the start of July, but it's soon lost from view as it nears solar conjunction on 2 September.

Jupiter

Best time to see: 1 July, 23:30 BST (22:30 UT)
Altitude: 15°
Location: Ophiuchus
Direction: South

Jupiter is low but bright at present. The planet reached opposition last month, so remains best placed for the current observing period. Unfortunately, any view of it will be affected by its low altitude as it tracks through the southern region of Ophiuchus. At mag. –2.4 it's easy to see during the early evening, but its altitude will drop over the night, the planet setting around 02:30 BST (01:30 UT) mid-month. A 90%-lit waxing gibbous Moon appears 1.5° above Jupiter on 13 July. The gas giant will start to become visible at July's end when it's at its highest point, around 15° up as seen from central UK as darkness falls.

Uranus

Best time to see: 31 July, 03:00 BST (02:00 UT)
Altitude: 29°
Location: Aries
Direction: East-southeast

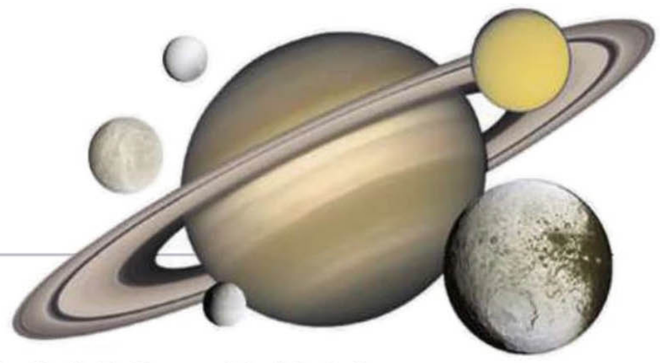
Uranus is not well placed at the start of July but does manage to attain an altitude in excess of 25° in reasonable darkness by the end of the month.

Neptune

Best time to see: 31 July, 02:45 BST (01:45 UT)
Altitude: 29.5°
Location: Aquarius
Direction: South-southeast

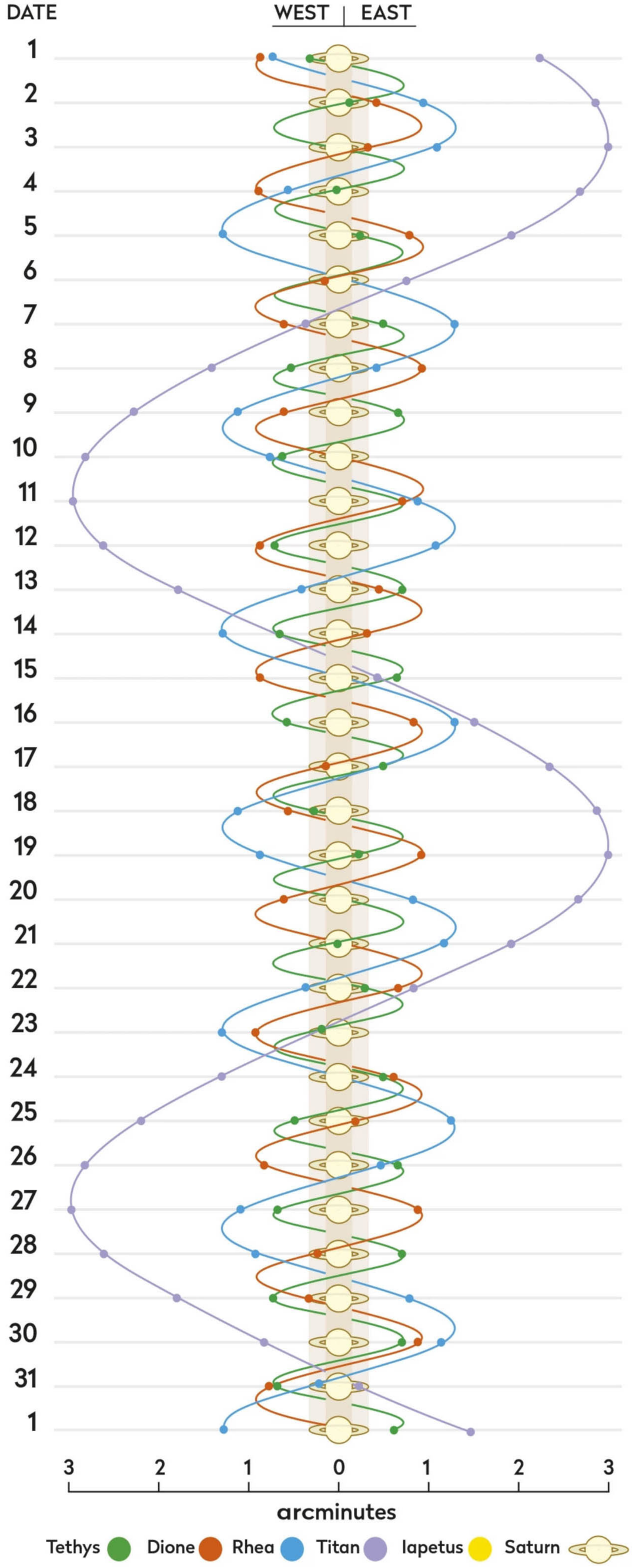
Views of Neptune improve as the nights expand and it shifts to the west. By 31 July, the mag. +7.8 planet is located 28° up in the south-southeast at 02:30 BST (01:30 UT).

More **ONLINE**
Print out observing forms for recording planetary events



SATURN'S MOONS: JULY

Using a small scope you can spot Saturn's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – JULY

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

5° N E W S — COMPASS AND FIELD OF VIEW

MILKY WAY

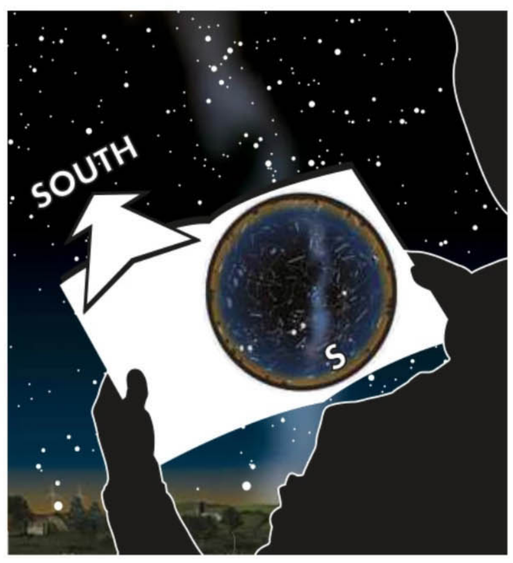
When to use this chart

1 July at 01:00 BST
15 July at 00:00 BST
31 July at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in July*

Date	Sunrise	Sunset
1 Jul 2019	04:46 BST	21:42 BST
11 Jul 2019	04:55 BST	21:35 BST
21 Jul 2019	05:08 BST	21:24 BST
31 Jul 2019	05:24 BST	21:08 BST

Moonrise in July*

Moonrise times

1 Jul 2019, 03:41 BST	17 Jul 2019, 22:05 BST
5 Jul 2019, 07:54 BST	21 Jul 2019, 23:36 BST
9 Jul 2019, 13:28 BST	25 Jul 2019, 00:44 BST
13 Jul 2019, 18:34 BST	29 Jul 2019, 02:14 BST

*Times correct for the centre of the UK

Lunar phases in July

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	2 NEW MOON	3	4	5	6	7
8	9	10	11	12	13	14
15	16 FULL MOON	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

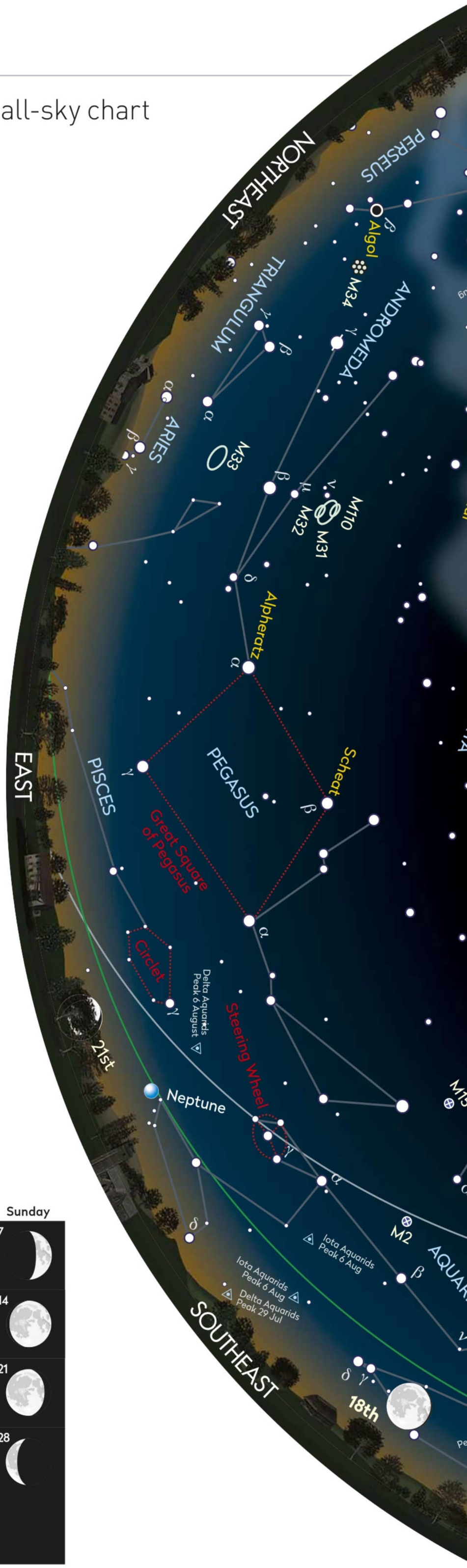
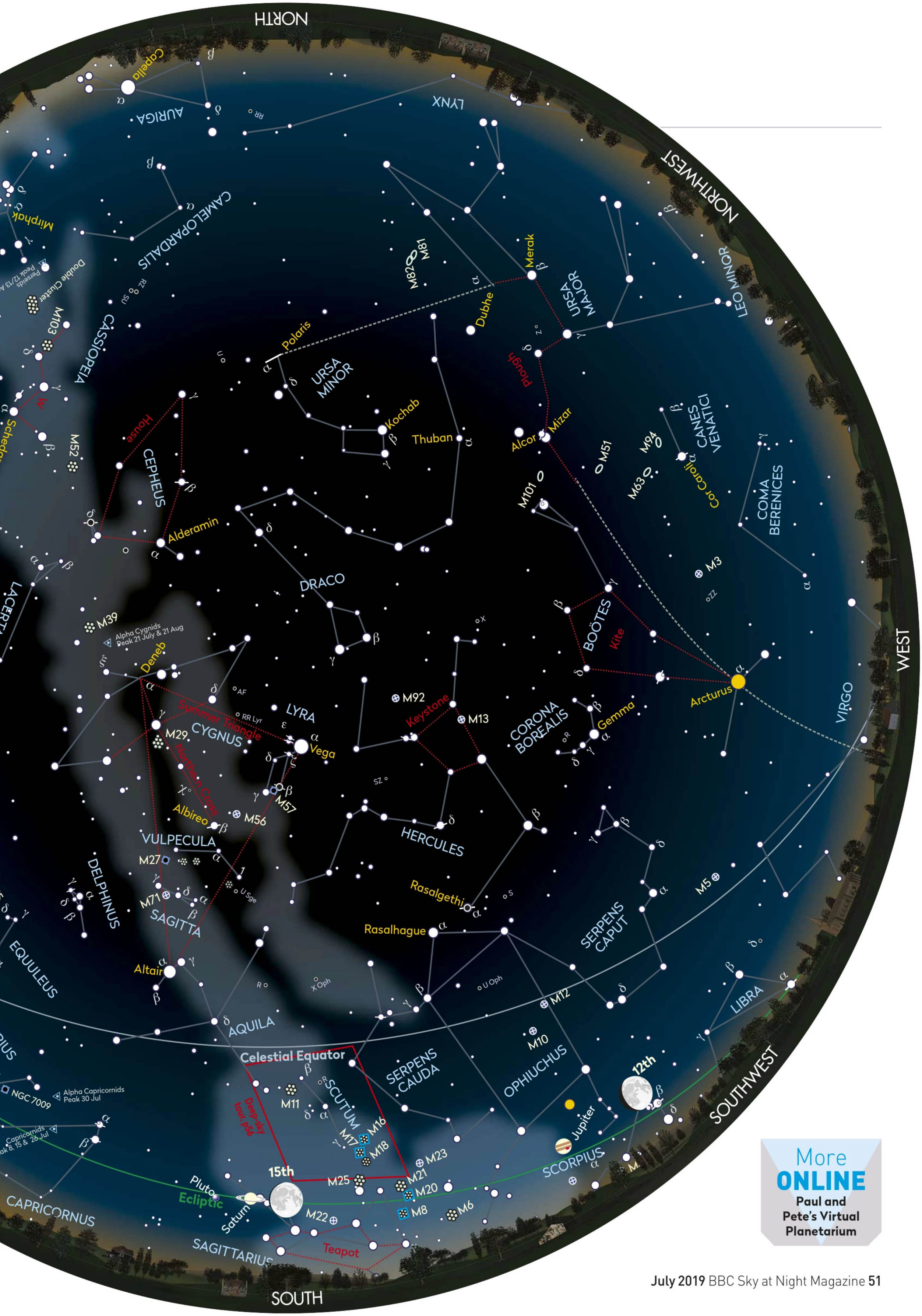


CHART: PETE LAWRENCE



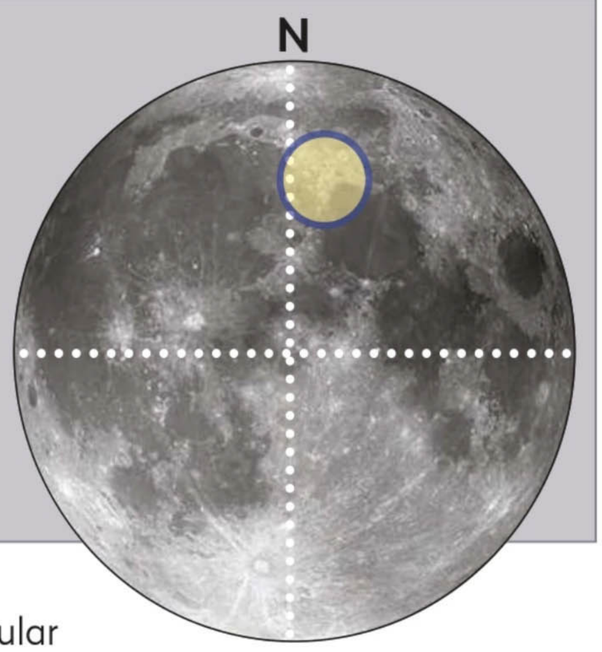
More **ONLINE**
Paul and Pete's Virtual Planetarium

MOONWATCH

July's top lunar feature to observe

Montes Caucasus

Type: Mountain range
Size: 520km x 100km
Longitude/latitude: 9.9° E, 37.5° N
Age: Between 3.2-3.9 billion years
Best time to see: 6 days after new Moon (8 & 9 July) and five days after full Moon (22 & 23 July)
Minimum equipment: 10x binoculars



Mountains on the Moon appear spectacular when the terminator – the line dividing lunar day and night – is nearby. Their height is beautifully accentuated by the long shadows cast when the Sun is low in the lunar sky. You'll see the effect with the **Montes Caucasus** range, running approximately north to south, between the Mare Imbrium and Mare Serenitatis. The Mare Imbrium sits between the lunar Alps to the north and Appennines to the south, and a gap between the southern end of the Caucasus range and northern end of the Apennines allows the Mare Imbrium and Serenitatis to touch.

When the Moon's terminator lies nearby, the shadows cast by the Caucasus range are very impressive

Starting at the southern end of the range a significant incursion of lava has flowed between the mountains, leading to a degree of isolation for some peaks. A number of fine grooves run to the west of the southern part of the range, a challenging sight for instruments with less than 300mm of aperture. The most prominent are the north-south grooves of **Rimae Theatetus**. Although they run for a length of 50km, they are only 2km wide at best. As ever, the best time to look for them is when the terminator is nearby.

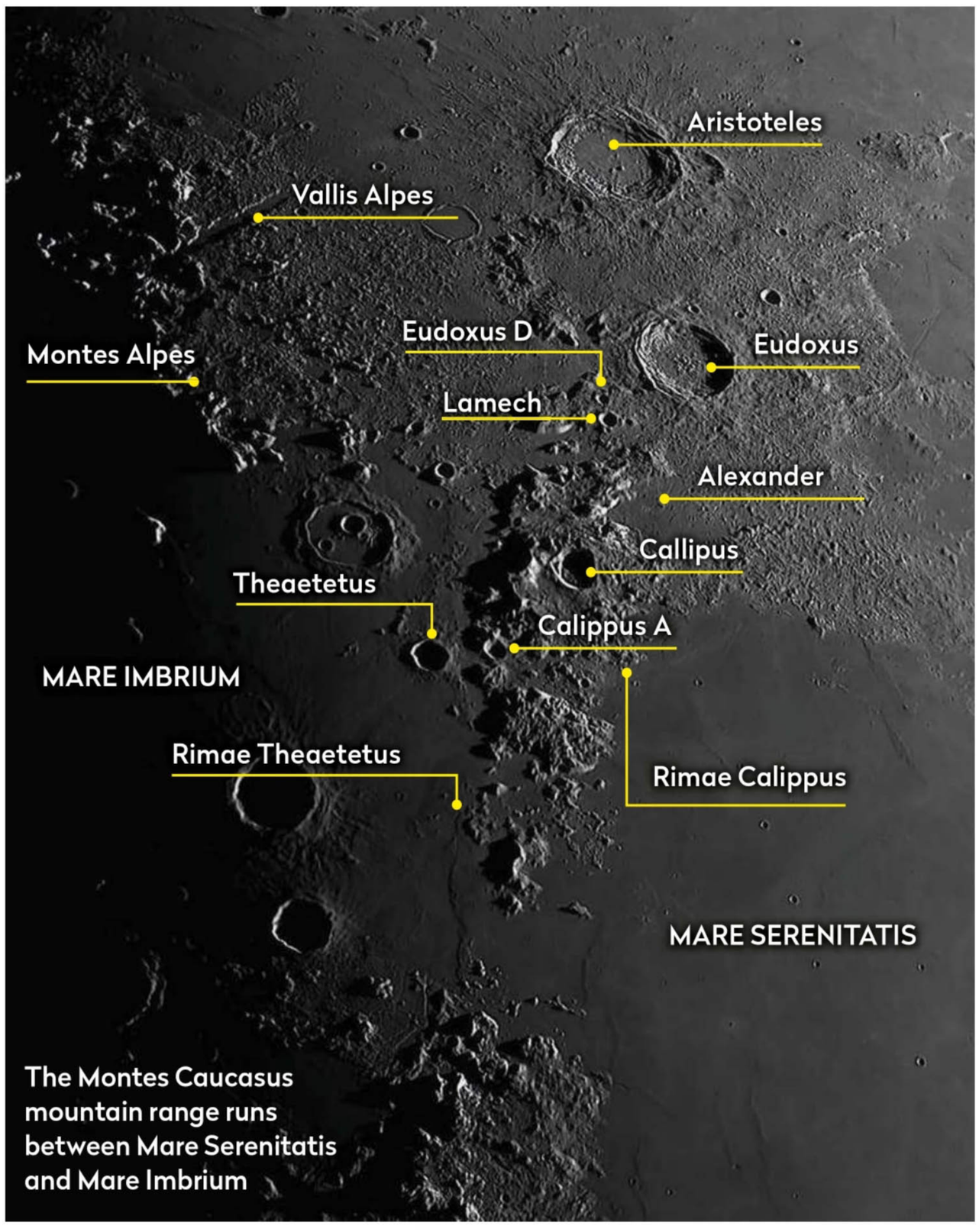
Heading north, the Caucasus range really begins to establish itself. An impressive curved, boomerang-shaped cliff delineates a prominent mountain massif from the floor of Mare Imbrium. To the west lies distinctive **Theaetetus**, a 25km diameter crater showing steep rim walls leading down to a flat floor. A short 44km hop to the east of Theaetetus brings us back into the Caucasus range and the 16km crater **Calippus A**. The mountains to the north of Calippus A rise to height approaching 6km, the highest in the range. The most impressive examples lie just to the west of 33km **Calippus**.

Another challenging set of grooves can be found 74km southeast of Calippus on the floor of Mare Serenitatis. Known as **Rimae Calippus**, these run for approximately 40km in length and are 1.5km-wide. Like Rimae Theaetetus mentioned earlier, Rimae Calippus really require an instrument over 300mm in diameter to resolve convincingly.

Continuing north, part of the range appears to form the western half of the rim of 83km **Alexander**, a rough eroded feature without significant definition to the east. When the Moon's morning terminator passes across this region (lunar co-longitude 342.1°) the rim peaks illuminate before the lower surrounding areas forming a curved chain of star-like points. This forms the clair-obscur effect known as Alexander's Beaded Rim.

North of Alexander the Caucasus range begins to peter out. A smaller massif is interrupted by the 13km crater **Lamech** with 10km-wide **Eudoxus D** 17km to its north. The impressive form of 68km **Eudoxus** sits to the east of the massif. Eudoxus forms a distinctive pair with 88km **Aristoteles**, both craters exhibiting superbly detailed terraces with bumpy but largely flat floors.

When the terminator lies nearby, at both waxing crescent and waning gibbous, the shadows cast by the Caucasus range across Mare Imbrium or northern Serenitatis respectively are very impressive and easily visible through a small scope.



The Montes Caucasus mountain range runs between Mare Serenitatis and Mare Imbrium

PETE LAWRENCE X 5

COMETS AND ASTEROIDS

Point a large telescope toward Sagittarius to spot the dwarf planet Pluto

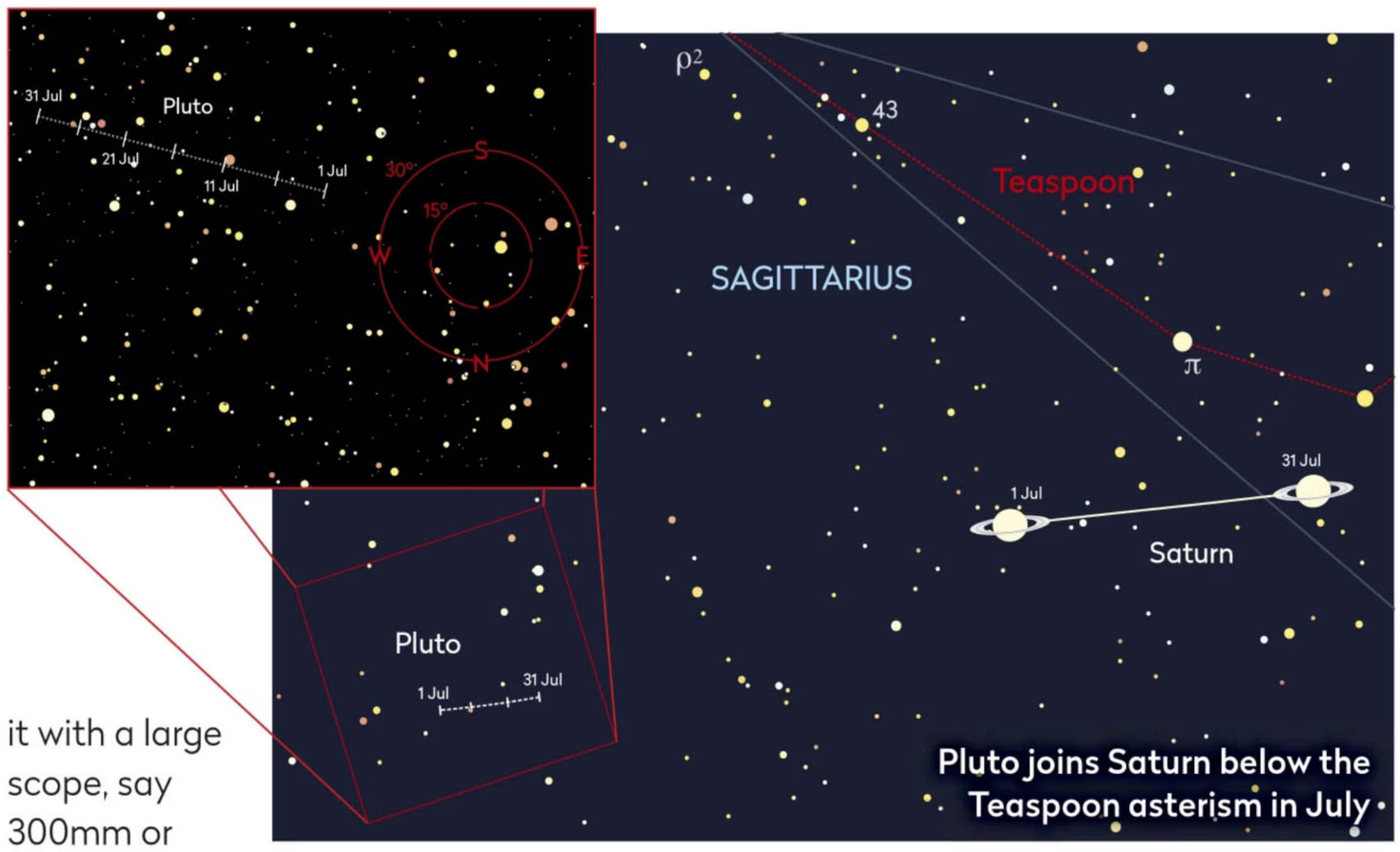
Pluto reaches opposition on 14 July. It's an object with various identities. It's known as a dwarf planet, having been demoted from main planet status in 2006. It's also referred to as a trans-Neptunian object (TNO), a Plutoid, a Kuiper Belt object (KBO) and a Plutino. The Minor Planet Centre (MPC) list it as Pluto (134340).

Imagined as a dark and distant world, we now know more about Pluto thanks to the 2015 flyby mission by the New Horizons spacecraft. It's a spherical body, 2,476km in diameter, with an orbit that varies its distance from the Sun between 49.3 AU and 29.7 AU. That orbit takes 248 years and is inclined to the ecliptic by 17.2°.

From an amateur perspective, Pluto remains a dim and distant, 14th magnitude target. No amateur scope can show anything other than a star-like point of light. Despite this, seeing the dwarf planet produces a sense of wonder.

Pluto is southeast of the Teaspoon asterism in Sagittarius in July. You can see it with a large scope, say 300mm or greater aperture, but there are claims of it being visible in smaller ones. From the UK its current position means it doesn't manage to climb out of the low horizon murk so this may restrict visibility.

A camera will fare better. Modern DSLRs are able to record down to 15th magnitude with ease under dark skies. Take images of the suspected area over several nights. Align them as layers in a graphics editor and blink the upper layer on and off (toggle its visibility) to compare it with the one below. Pluto will be shown as a faint dot moving relative to the background stars.



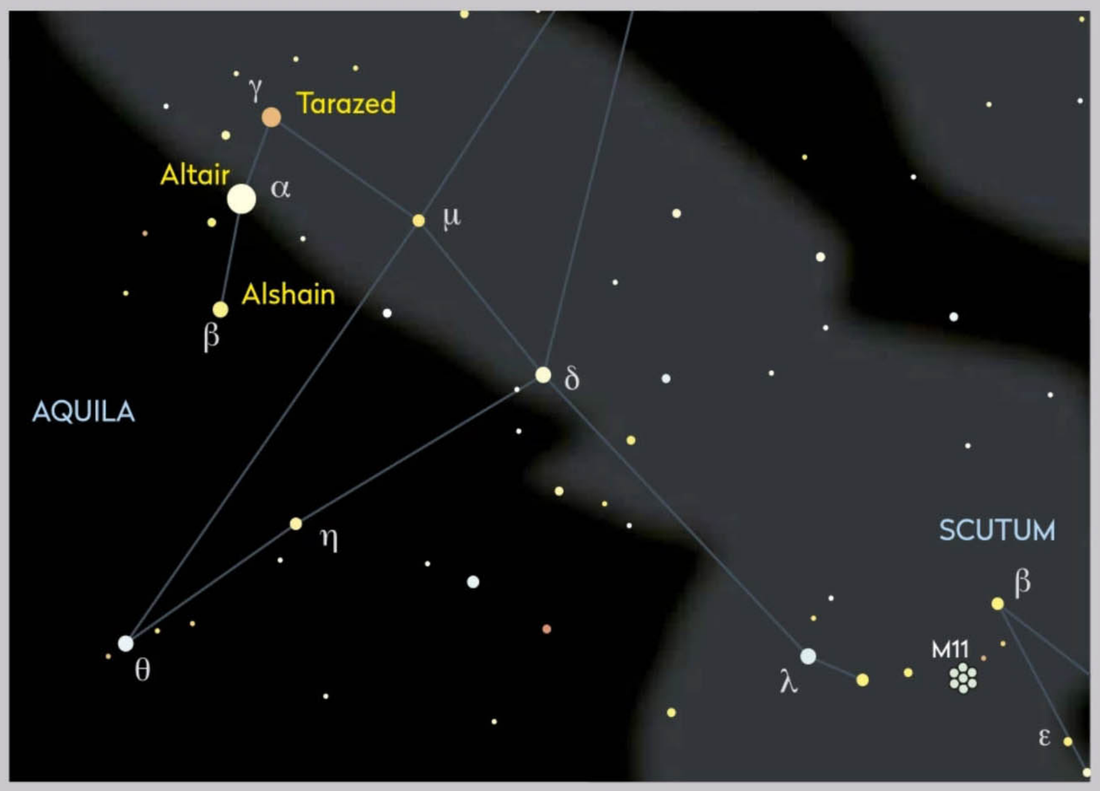
STAR OF THE MONTH

Eta Aquilae, a prominent Cepheid variable star

Eta (η) Aquilae is an unassuming, fourth magnitude star in the constellation of Aquila the Eagle. It sits slightly less than 8° south of Aquila's principal star, Altair (Alpha (α) Aquilae). In mythology Eta represents the head of Antinous, which is depicted being carried by the eagle.

Although it may not look that impressive, Eta Aquilae belongs to an important class of star known as the Cepheid variables. Eta Aquilae was the first Cepheid recognised to exhibit variability following observations by Edward Pigott in 1784. But it was his friend, John Goodricke who is credited as discovering the periodic nature of Delta (δ) Cephei, the prototype of the class. Delta Cephei marks the southeast corner of the constellation of Cepheus the King.

The Cepheid category of stars is important because they exhibit a precise period of variability which is intrinsically linked to their luminosity, a property discovered by Henrietta Swan Leavitt in 1908. If you measure a Cepheid's period you can determine what its absolute magnitude is. Absolute magnitude is the brightness a star would shine at from a standard distance of 10 parsecs (32.6 lightyears).

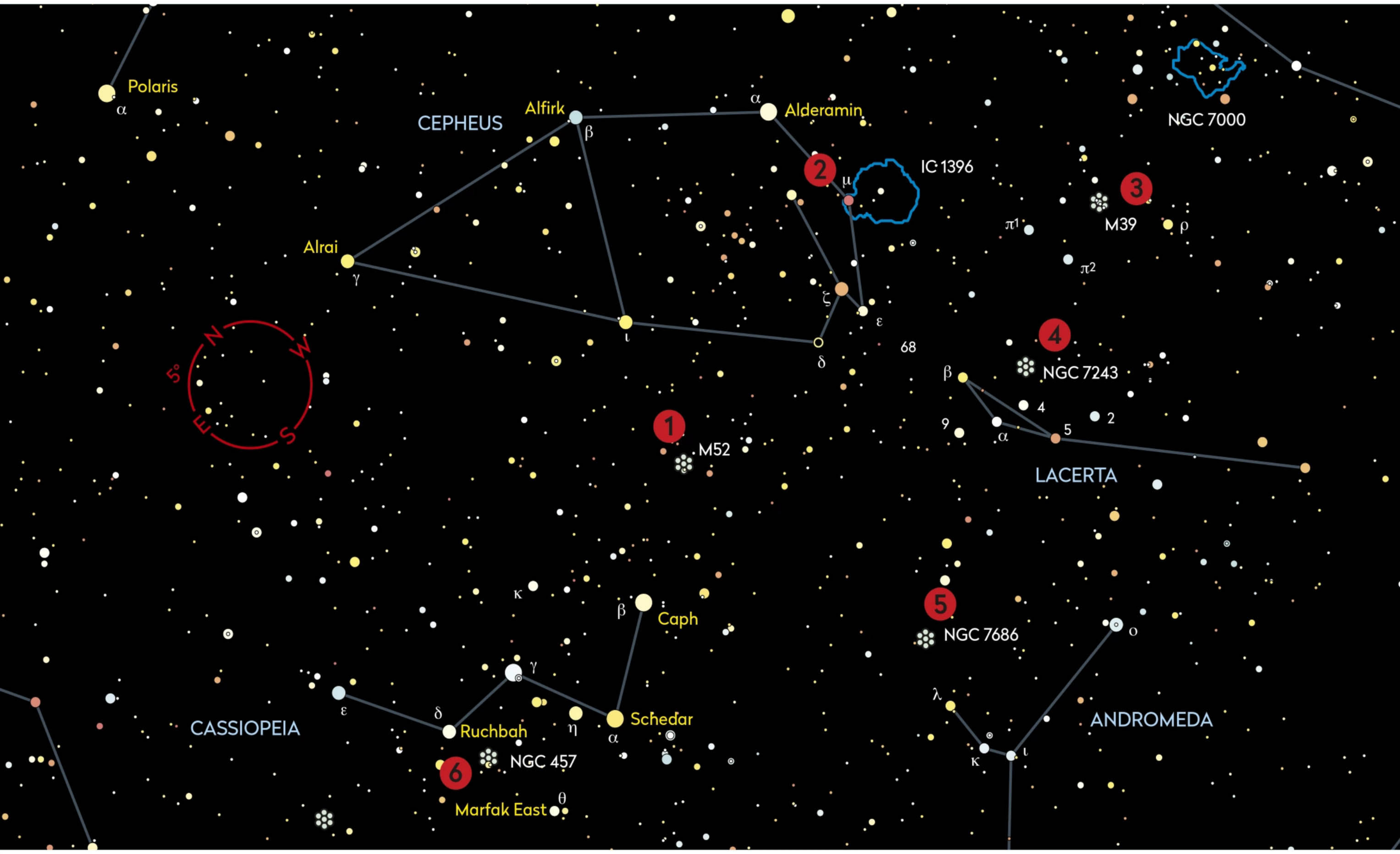


▲ **Eta (η) Aquilae, south of Altair, can be seen with the naked eye**

Eta Aquilae exhibits a variation of between mag. +3.6 and +4.4 over a period of 7 days, 4 hours, 14 minutes and 22 seconds. At this brightness it is one of the prominent Cepheids in the sky, easily observable with the naked eye.

BINOCULAR TOUR With Stephen Tonkin

Wide-field gems include the garnet star that impressed astronomer William Herschel



PETE LAWRENCE X 3

1 M52

10x 50 The grainy glow of the 52nd object in Charles Messier's catalogue was discovered, by chance in 1774 by the man himself, when Comet Montaigne passed nearby. It's easy to find, being in a straight line with Shedar (Alpha (α) Cassiopeiae) and Caph (Beta (β) Cassiopeiae), 6° northwest of Caph. You can differentiate its 13 arcminute wedge-shaped glow from the Milky Way, but you'll only be able to resolve one mag. +8.3 star. ☐ **SEEN IT**

2 Herschel's Garnet Star

10x 50 Just south of the mid-point of a line between Alderamin (Alpha (α) Cephei) and Zeta (ζ) Cephei is the deep orange mag. +4.0 Mu (μ) Cep, named for William Herschel. Can you replicate his 1783 description of this red supergiant star: "very fine deep garnet colour and a most beautiful object, especially if we look for some time at a white star before we turn to it, such as Alpha Cephei." ☐ **SEEN IT**

3 M39

10x 50 M39 makes a right isosceles triangle with Pi-2 (π2) and Rho (ρ) Cygni, and will be near the centre of the field of view of 10x50 binoculars if you place the stars at the edge. The number of stars you will see depends on your sky conditions: an urban sky reveals only four or five but, if it's dark enough to see the cluster with your naked eye, you should see at least 15 through your binoculars. ☐ **SEEN IT**

4 NGC 7243

10x 50 Our next target, NGC 7243, also designated Caldwell 16, is 1.5° west of mag. +4.6 star 4 Lacertae. Although it's in a bright part of the Milky Way, you should be able to distinguish 12 or so stars of this coarse cluster. A dark lane separates them into two groups, with the eastern group about half the size of the western one. The absence of background glow suggests that you are resolving nearly all the stars. ☐ **SEEN IT**

5 NGC 7686

10x 50 Use the chart to find Kappa (κ) and Lambda (λ) Andromedae and extend a line joining them the same distance northwards, to an obvious pair of stars, the brighter at mag. +6.2. Allow your eyes to relax and the 15 arcminute diameter glow of the background cluster will become visible, but you'll only be able to resolve three more individual stars unless you switch to larger binoculars. ☐ **SEEN IT**

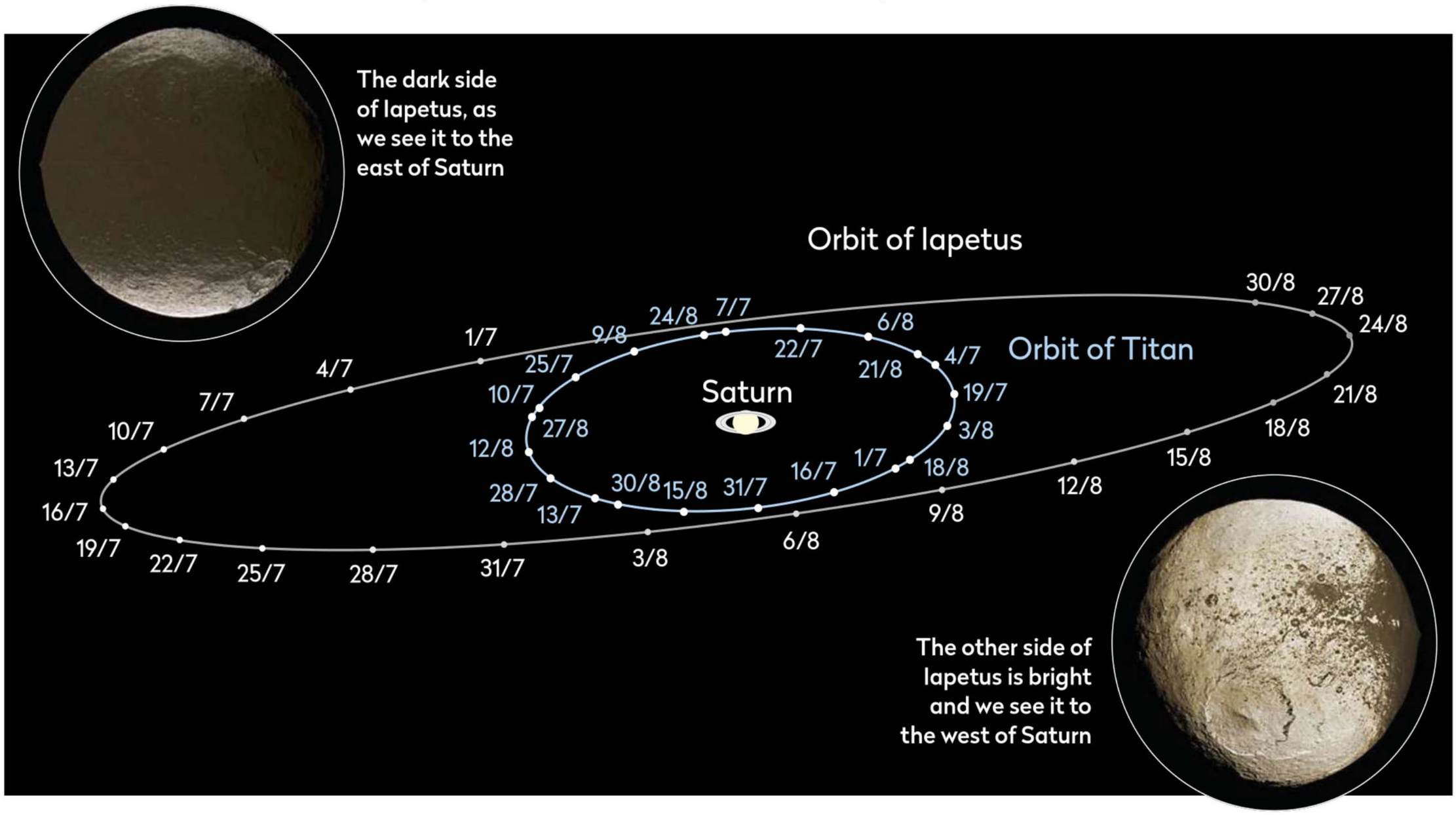
6 The Owl Cluster (NGC 457)

15x 70 Start at Ruchbah (Delta (δ) Cassiopeiae), then identify Marfak-East (Theta (θ) Cassiopeiae) and pan 2° towards it. Here you'll find a double star, the Owl's Eyes, shining at mag. +5 and +7. The brighter eye is not part of the cluster, but only half as distant. The Owl's body and wings are composed of 9th and 10th magnitude stars. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

THE SKY GUIDE CHALLENGE

This month we look at Iapetus, Saturn's walnut-shaped moon



▲ A south-up view through a scope of shows Saturn's moon Iapetus relative to its largest moon Titan, during July and August

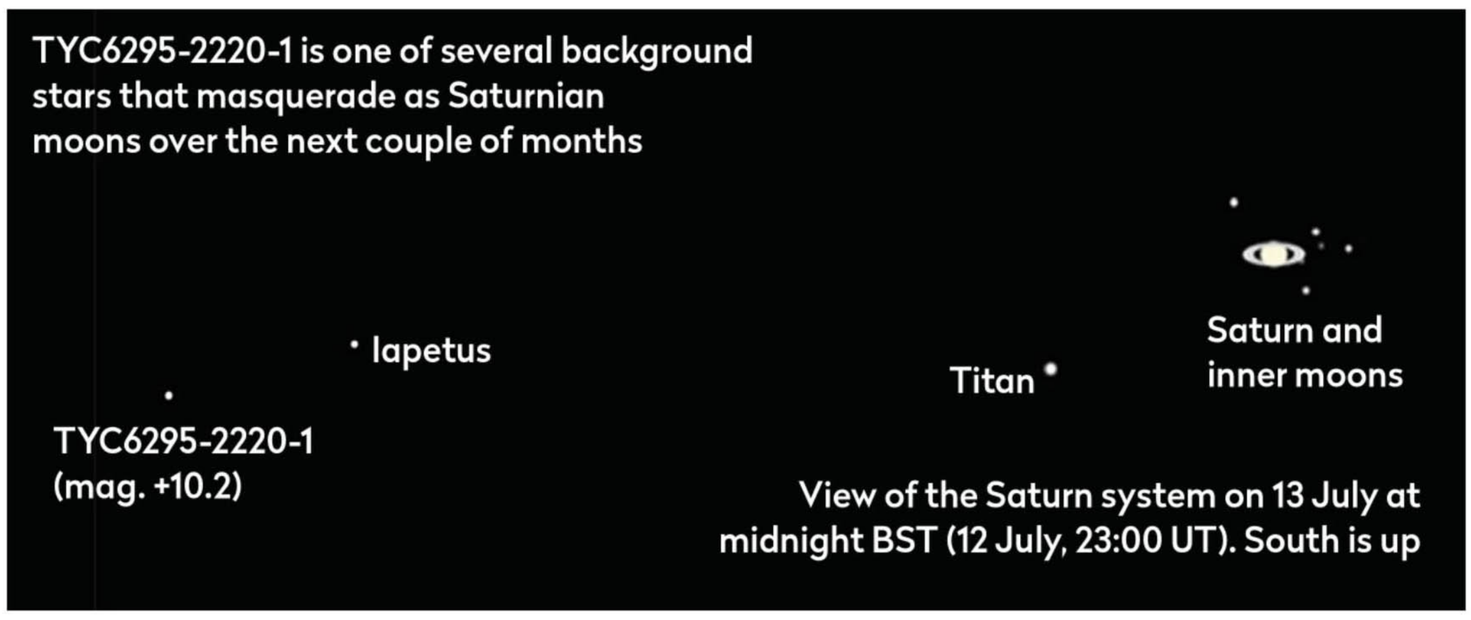
Like giant Jupiter, Saturn has an extensive family of moons, 62 of which have formal designations. One of these is a curious object called Iapetus. It's approximately 1,460km in diameter but its overall shape is a little odd. It has a composition which is around 80 per cent ice and bulges at the waistline. In addition, there's a curious equatorial ridge, which runs for a distance of 1,300km. It's 20km wide and rises to a height of 13km. From a distance, combined with the waistline bulge, Iapetus is often described as looking like a walnut.

It's the third largest moon of Saturn and the 11th largest in the Solar System. Iapetus orbits Saturn once every 79.3 days, the same time it takes to rotate once on its axis. This means that it's synchronously locked to Saturn – like our Moon it always presents the same face towards the planet. Interestingly, Iapetus also has the largest inclination of all the Saturnian satellites, its orbit being tilted by 15.5° to Saturn's equatorial plane. Any future astronaut on the moon's planet-facing surface would have a great view of Saturn's rings.

The discovery of Iapetus hinted at something odd. It was discovered by Giovani Cassini in 1671 when it was visible to the west of the planet. However, when it moved to the eastern side it disappeared from his view, an observation which he found repeated over time. Bringing in a better telescope in 1705 he finally saw it on the eastern side of Saturn where it appeared 2 magnitudes dimmer than when positioned to the west.

We now know that Iapetus is a moon of two halves. One half is covered with dark material and is the side facing us when we see it to the east of Saturn. The other half is bright. From Earth, the bright half appears at mag. +10.2 while the dark region (incidentally named Cassini Regio) shines at mag. +11.9.

During July, Iapetus will be to the west of Saturn and hence appear brightest. It approaches western elongation mid-month and interestingly, in the early hours of 13 July is joined by the mag. +10.2 background star TYC6295-2220-1. Here, care will be needed to make sure you have the right mag. +10.2 object – Iapetus being the one closest to Saturn on the morning of 13 July with the star appearing closer to the planet on 14 July. Iapetus reaches elongation on 16 July. The next eastern (dim) elongation is on 23 August making this summer a great time to watch or image the orbital fade. Visually, we would recommend using a 100-150mm aperture instrument.



DEEP-SKY TOUR

From the Wild Duck Cluster, via a heart-shaped Scutum cloud, to the striking Eagle Nebula

1 M11

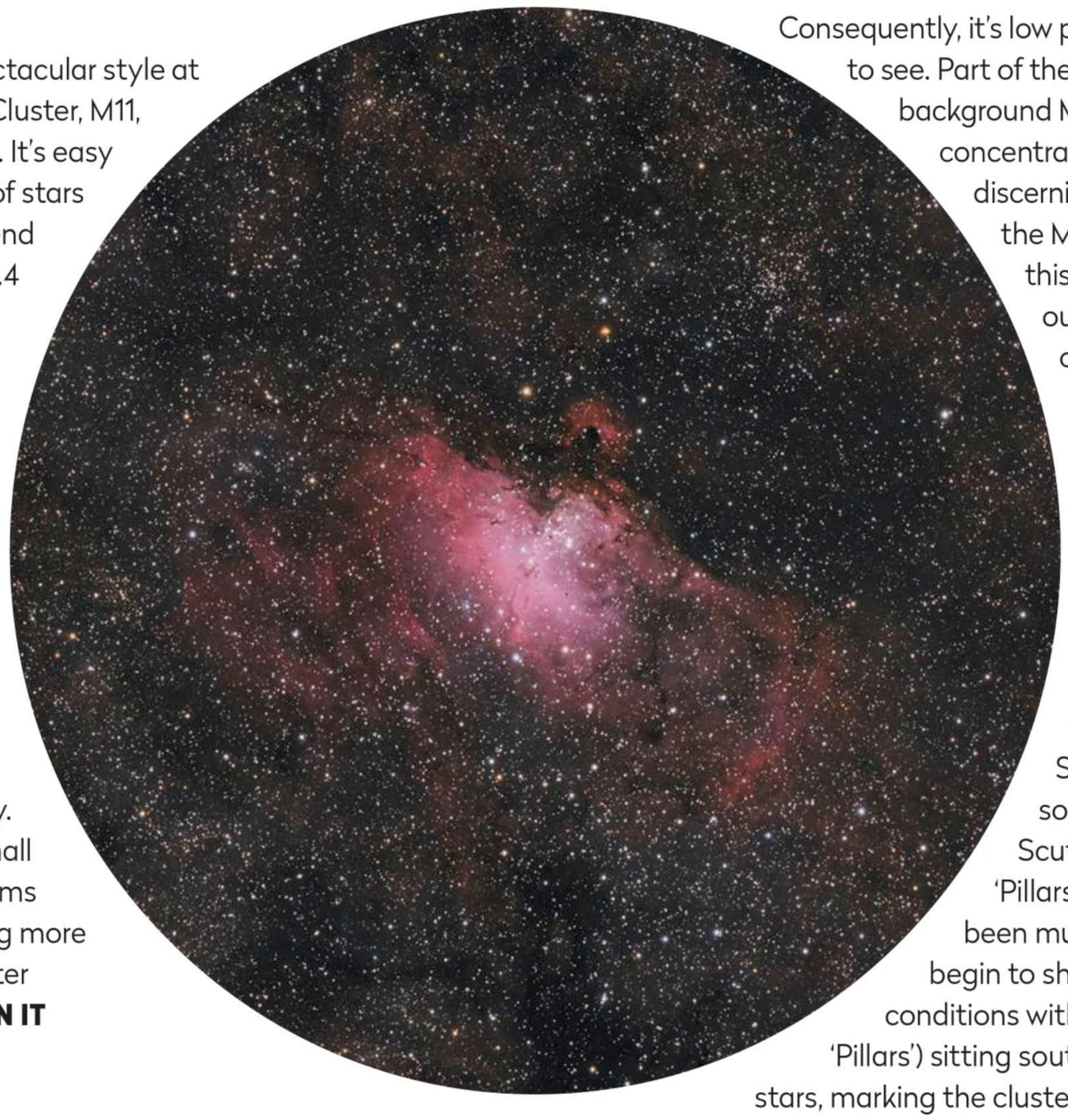
We start in spectacular style at the Wild Duck Cluster, M11, an open cluster in Scutum. It's easy to find, continuing an arc of stars which lie at the southern end of Aquila. Start at mag. +3.4 Althalimain (Lambda (λ) Aquilae), moving on to mag. +4.0 12 Aquilae, then mag. +4.8 Eta (η) Scuti before arrival at M11. This sixth magnitude cluster will take your breath away through an eyepiece. It contains around 2,900 stars with 500 brighter than 14th magnitude. It's estimated to be 6,120 lightyears away. It resolves well through small instruments and overwhelms through large ones, looking more like a broken globular cluster than an open one. ☐ **SEEN IT**

2 NGC 6712

Leaving the Wild Duck, head 2.5° south to locate the mag. +8.0 globular NGC 6712, also in Scutum. Although small, the diamond-shaped constellation holds favour for naked-eye astronomy as it contains the Scutum Star Cloud, a heart-shaped brightening of the Milky Way. It's said that NGC 6712 was discovered by Le Gentil in 1749 while investigating this cloud. A 150mm scope should resolve some cluster members, but a large instrument is required to finish the job. An ESO study of the cluster suggests that this small globular is what remains of a far larger example. NGC 6712's stars are all larger than the Sun and the cluster is unique in that it passes closer to the core of our Galaxy than any other globular. ☐ **SEEN IT**

3 NGC 6664

For our next target, open cluster NGC 6664, head 4.5° west. Actually, locating the cluster isn't difficult as it sits 22 arcminutes east of mag. +3.8 Alpha (α) Scuti. Of all the objects we've looked at so far this is the hardest. It's listed as a mag. +7.8 cluster with an apparent diameter of 12 arcminutes. However, it's sparse and has low surface brightness. Consequently, it's low powers that make it easier to see. Part of the problem is the background Milky Way. Being weakly concentrated, NGC 6664 has no discernible edge. Located against the Milky Way's background, this makes it tricky to pick out. A relatively young object at 14.5 million years of age, this is estimated to be 3,800 lightyears distant. ☐ **SEEN IT**



▲ **The magnificent Eagle Nebula, M16, reveals a silhouetted bird of prey**

4 M16

M16, the Eagle Nebula, is an emission nebula with embedded cluster stars in Serpens Cauda. It lies 7° south-southwest of Alpha Scuti. M16 includes Hubble's 'Pillars of Creation' and has been much imaged. Large scopes begin to show it under dark sky conditions with the brightest part (the 'Pillars') sitting south of mag. +8.9 and +9.3 stars, marking the cluster's southeast edge. Dark lanes silhouetted against the nebulosity depict the outline of an eagle with a fish in its talons. The overall glow resembles an eagle's spread wings. ☐ **SEEN IT**

5 M17

Transform your view from an eagle to a swan by heading 2.5° south of M16 to M17, the Swan Nebula. It's a beautiful nebula, much easier to see than M16. It survives magnification well, presenting detail at different powers. It lies (just) in the constellation of Sagittarius, shining with an integrated magnitude of +6 and appearing 11 arcminutes across. A central 'bar' of nebulosity stands out well and, as your eyes get used to the view, a curved nebulous patch hangs to the south. This is the Swan's neck, the bird being upside down – of course. ☐ **SEEN IT**

6 M18

Our final object is perhaps a little less dramatic than the previous fare, but it's nonetheless interesting in its own right. M18 is a mag. +7.5 open cluster, which lies less than 1° south and west of M17. This is a young object with an age estimated to be around 32 million years. It is located 4,230 lightyears from Earth. Visually, the cluster has an apparent diameter of around 5 arcminutes and appears sparse. It lies to the north of the Sagittarius star cloud (M24), but within a region of the Milky Way that appears less dense. As a result the 20-25 stars which form the cluster stand out well. ☐ **SEEN IT**

CEDIC TEAM/CHRISTOPH KALTSEIS/CCDGUIDE.COM, CHART BY PETE LAWRENCE

This Deep-Sky Tour has been automated ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**

Print out this chart and take an automated Go-To tour. See page 5 for instructions.

AQUILA

SCUTUM

SERPENS CAUDA

19h00m

18h30m

-05°

-10°

-15°

λ

Althalimain

12

η

NGC 6704

β

Trumpler 35

R

Basel 1

M11

1

η

NGC 6712

2

M26

ε

δ

3

NGC 6664

α

Trumpler 34

NGC 6649

ζ

GUM 84-85

NGC 6625

NGC 6604

4

M16

γ

NGC 6605

5

M17

NGC 6645

NGC 6647

M18

6

Collinder 469

5°

2°

N

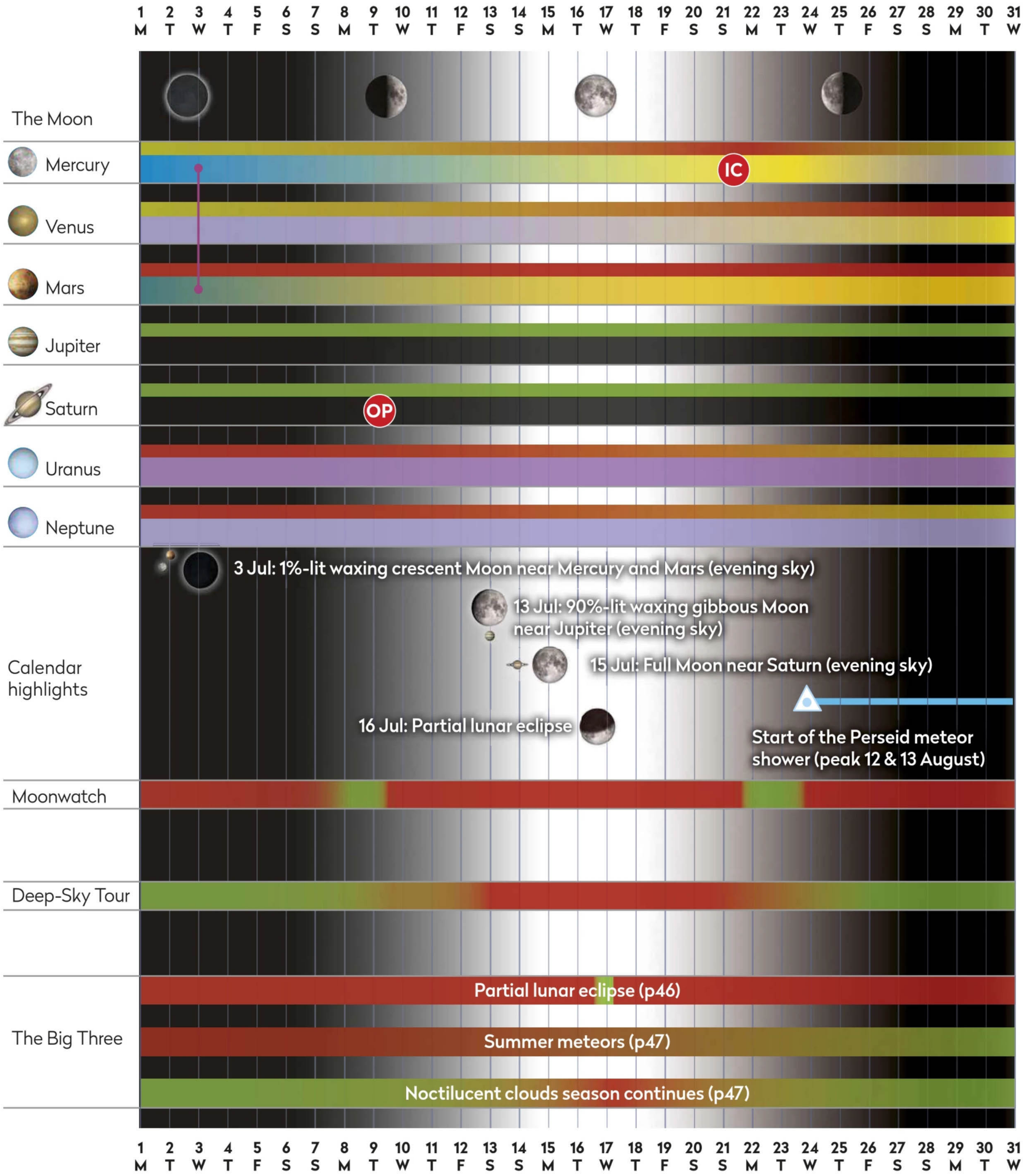
E

W

S

AT A GLANCE

How the Sky Guide events will appear in July



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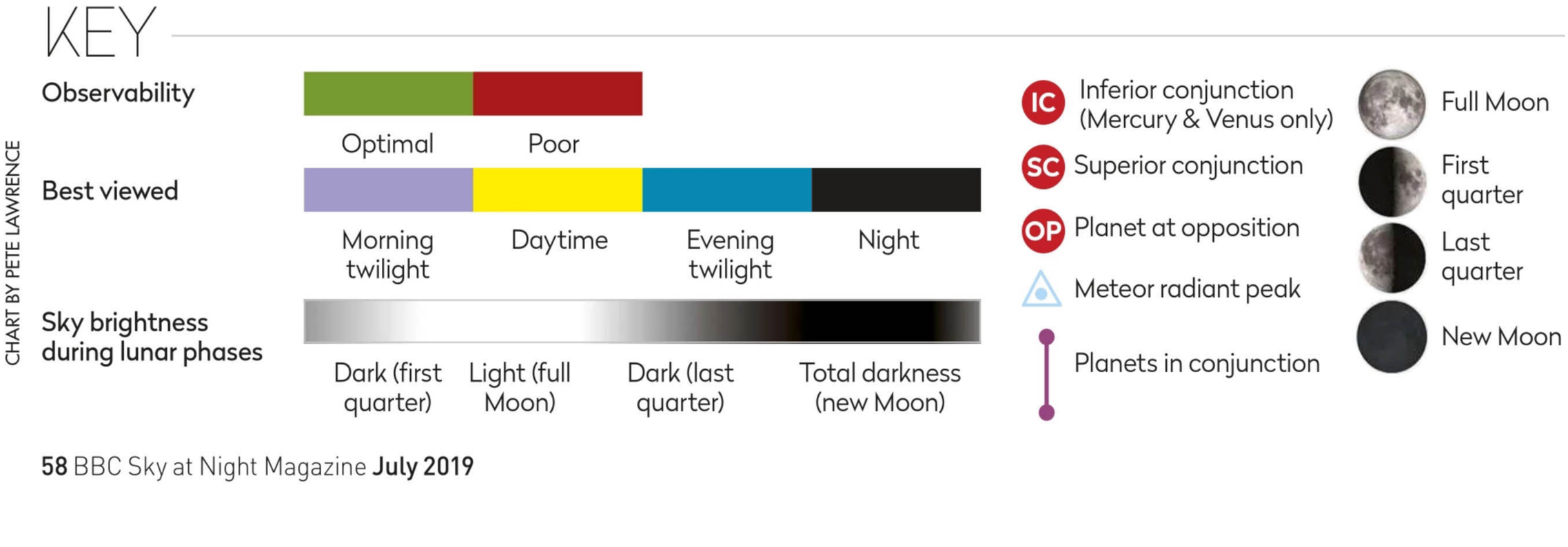
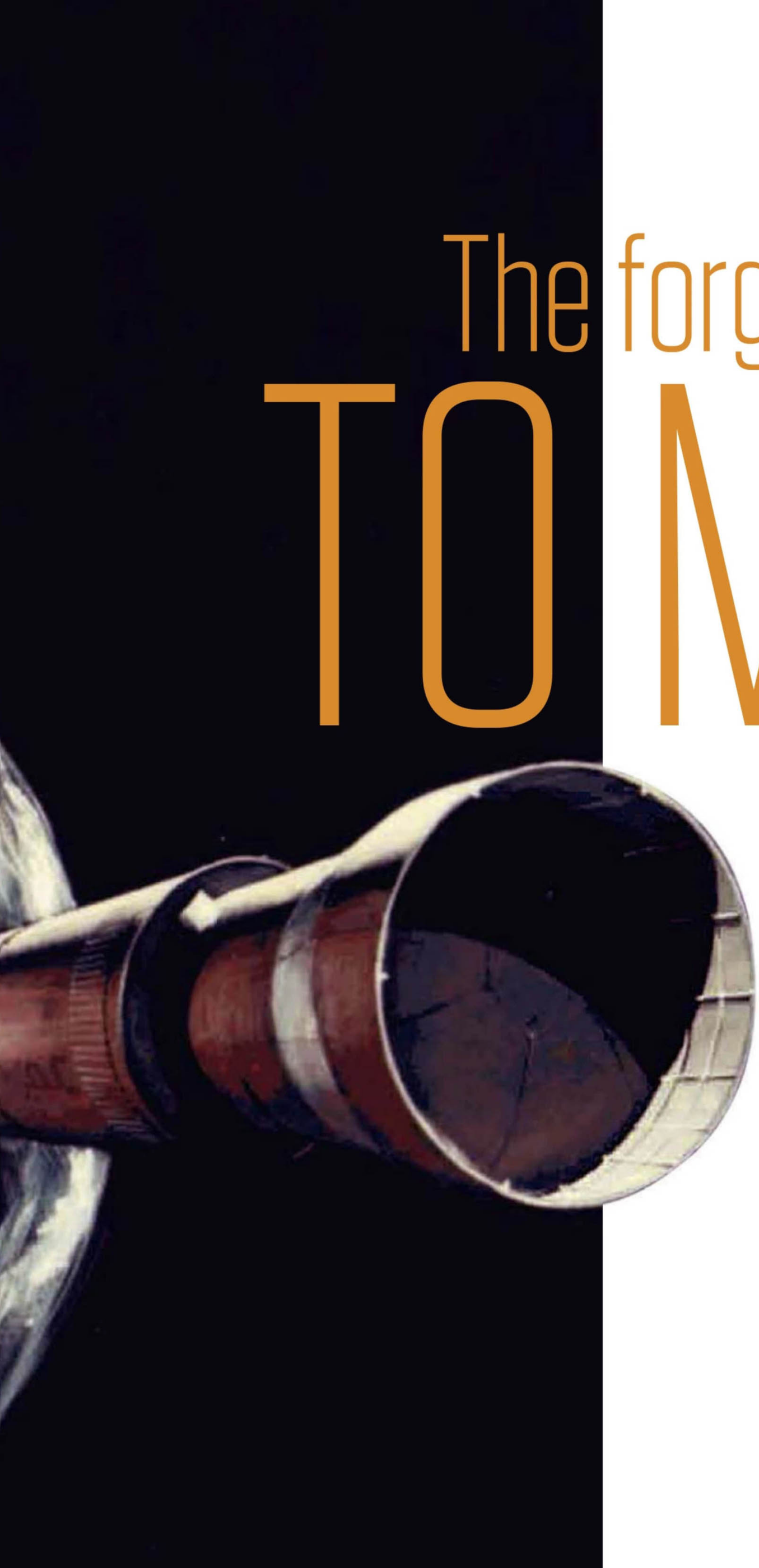


CHART BY PETE LAWRENCE

The forgotten mission TO MARS



Apollo's mastermind, Wernher von Braun, planned a crewed mission to the Red Planet by the 1980s. But what actually happened was a different story, writes former NASA scientist **David Baker**

Within weeks of Neil Armstrong landing on the Moon in July 1969, a German-born rocket engineer was masterminding a plan to send human expeditions to Mars, in an attempt to reach deeper into the Solar System.

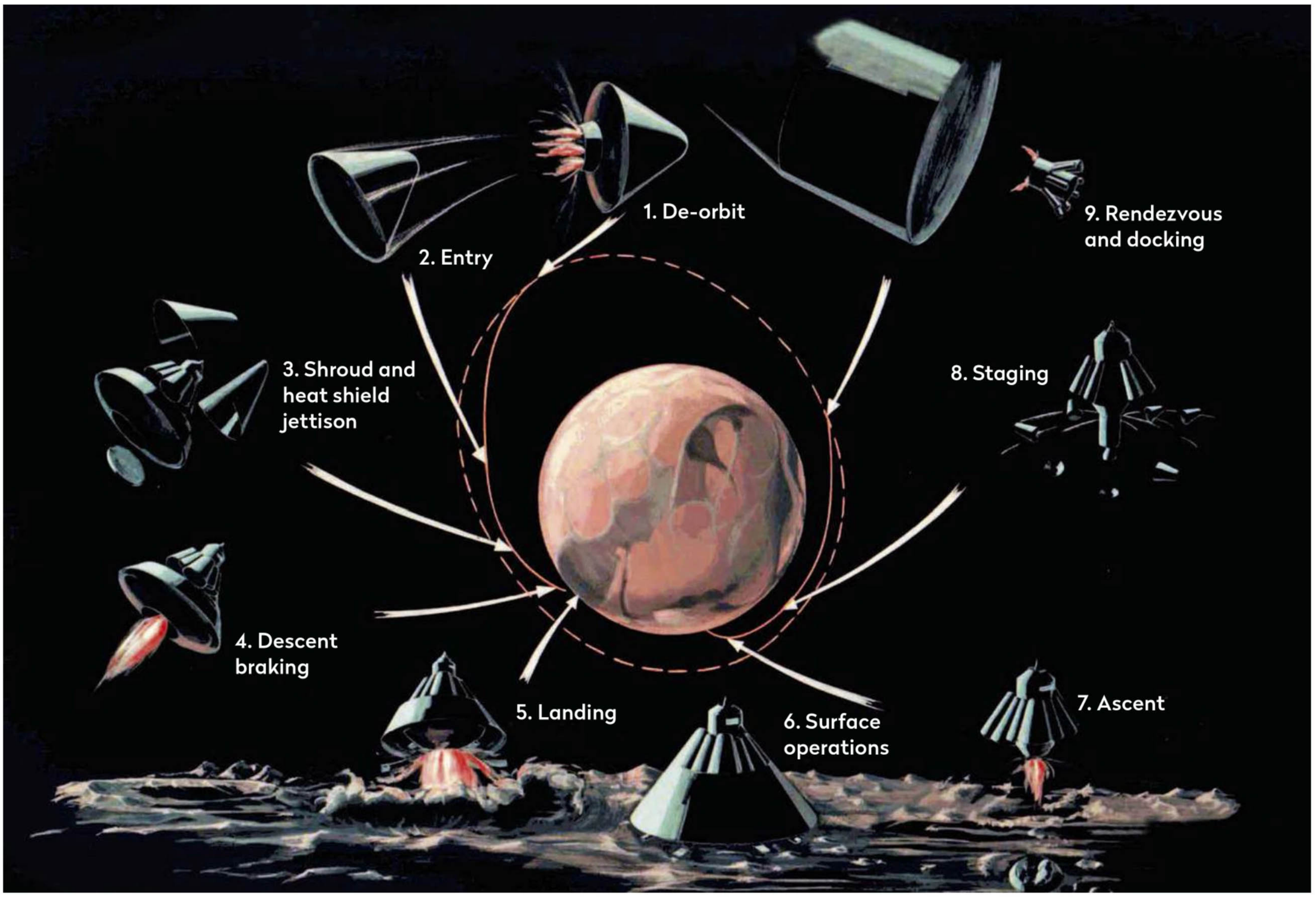
The decision to send astronauts to the Moon came after Soviet cosmonaut Yuri Gagarin became the first human in space on 12 April 1961. Within weeks the newly incumbent US President John F Kennedy responded to recommendations from senior managers at NASA to put Americans on the Moon by the end of that decade. Critical to achieving that was rocket power and a very big launcher, the Saturn V, engineered by Wernher von Braun.

A staunch advocate of space travel, von Braun had made a deep impression on NASA engineers. Originally funded by the army, his Saturn launch vehicles were taken over by NASA from 1960 to form the benchmark for studies on how to extend human space travel to distant destinations.

By the mid 1960s, NASA was searching for ways to use Apollo-era hardware for extended visits to the lunar surface and to support Earth-orbiting space stations throughout the 1970s. But funds to develop ▸

◂ An archive illustration from Wernher von Braun's *Manned Mars Landing Presentation To The Space Task Group* shows a ship departing from Mars at the end of a crewed mission

MARSHALL SPACE FLIGHT CENTER/NASA



▲ **Von Braun's ambitious 1969 Mars mission plan included a return trip to the Red Planet's surface**

MARSHALL SPACE FLIGHT CENTER/NASA X 4, NASA/MSFC

► these ideas never materialised and, with budgets already waning by the time the first Moon landing took place, the future of human spaceflight was in dire threat.

Radical new concepts were essential to mobilising support for a sustainable future space programme after Apollo. As early as 1967, NASA was already moving toward replacing its expendable rockets with a reusable shuttle that would be capable of frequent flights to Earth orbit. From there, spacecraft could launch to the Moon and Mars.

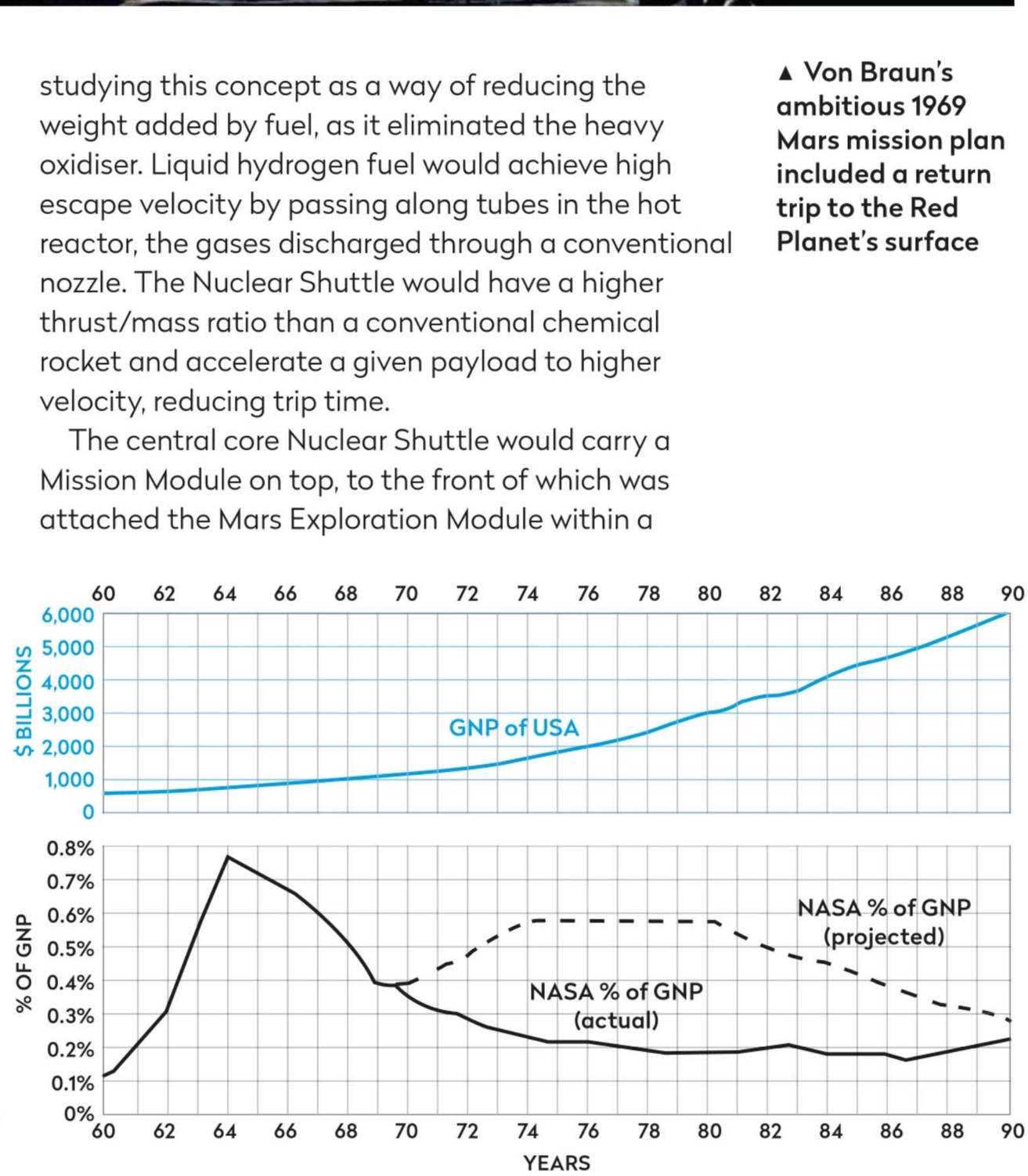
Man with a plan

By 1968 NASA realised it would have to reduce the cost of spaceflight by reusing hardware, and the concept of 'commonality' was added to 'reusability'. These became the mantra for studies conducted at NASA field centres in a search for what became known as the Integrated Space Program.

Accepted as the ultimate strategist, in 1969 von Braun devised a Mars mission plan involving four key elements. These comprised the Saturn V, Nuclear Shuttle, Mars Mission Module and a Mars Excursion Module for a single flight to Mars and back. It also required the availability of the Space Shuttle and continued production of the Saturn V.

The mission would begin in Earth orbit by clustering three Nuclear Shuttles in parallel: cylindrical rocket stages each using a nuclear reactor in place of a chemical combustion motor. NASA had been studying this concept as a way of reducing the weight added by fuel, as it eliminated the heavy oxidiser. Liquid hydrogen fuel would achieve high escape velocity by passing along tubes in the hot reactor, the gases discharged through a conventional nozzle. The Nuclear Shuttle would have a higher thrust/mass ratio than a conventional chemical rocket and accelerate a given payload to higher velocity, reducing trip time.

The central core Nuclear Shuttle would carry a Mission Module on top, to the front of which was attached the Mars Exploration Module within a



▲ **After the Apollo years, the amount of gross national product (GNP) allocated to NASA declined, curtailing von Braun's plans for crewed Martian missions**

Life after Apollo

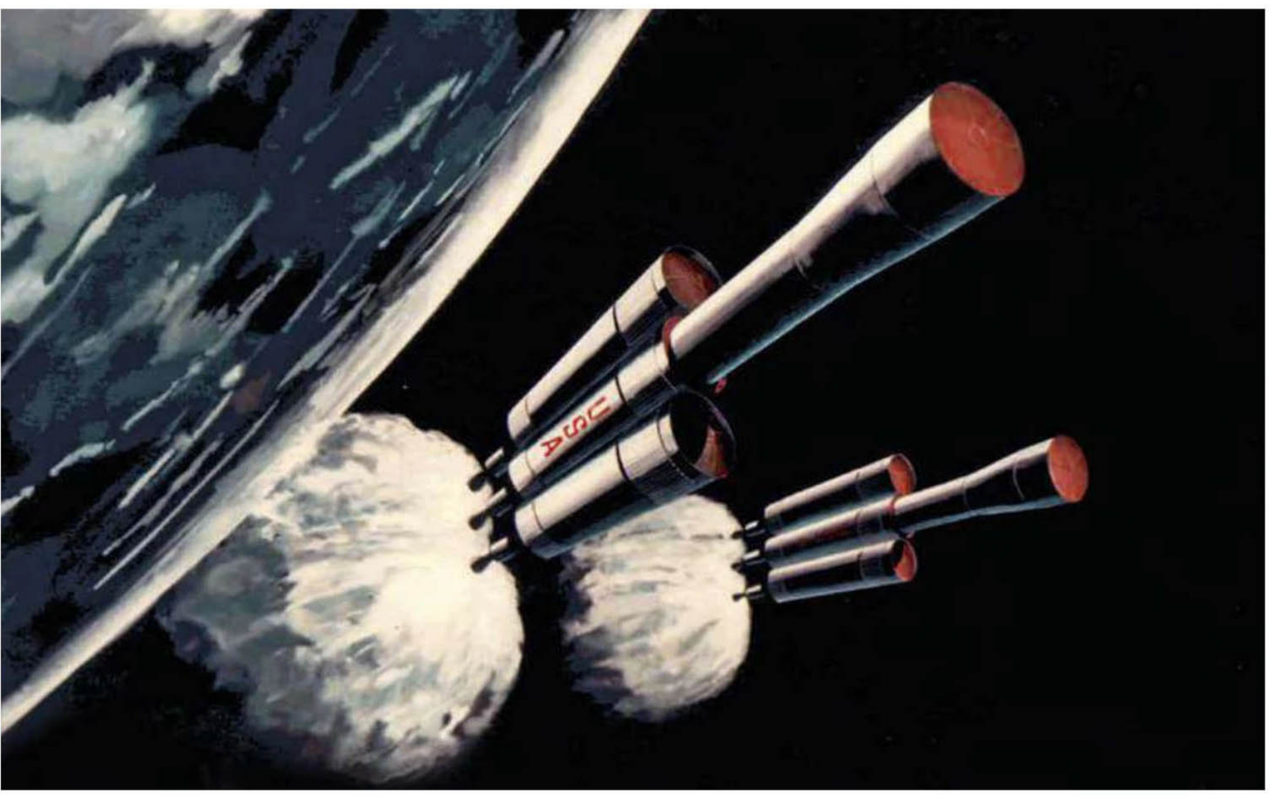
Von Braun never again reached the dizzy heights of putting humans on the Moon

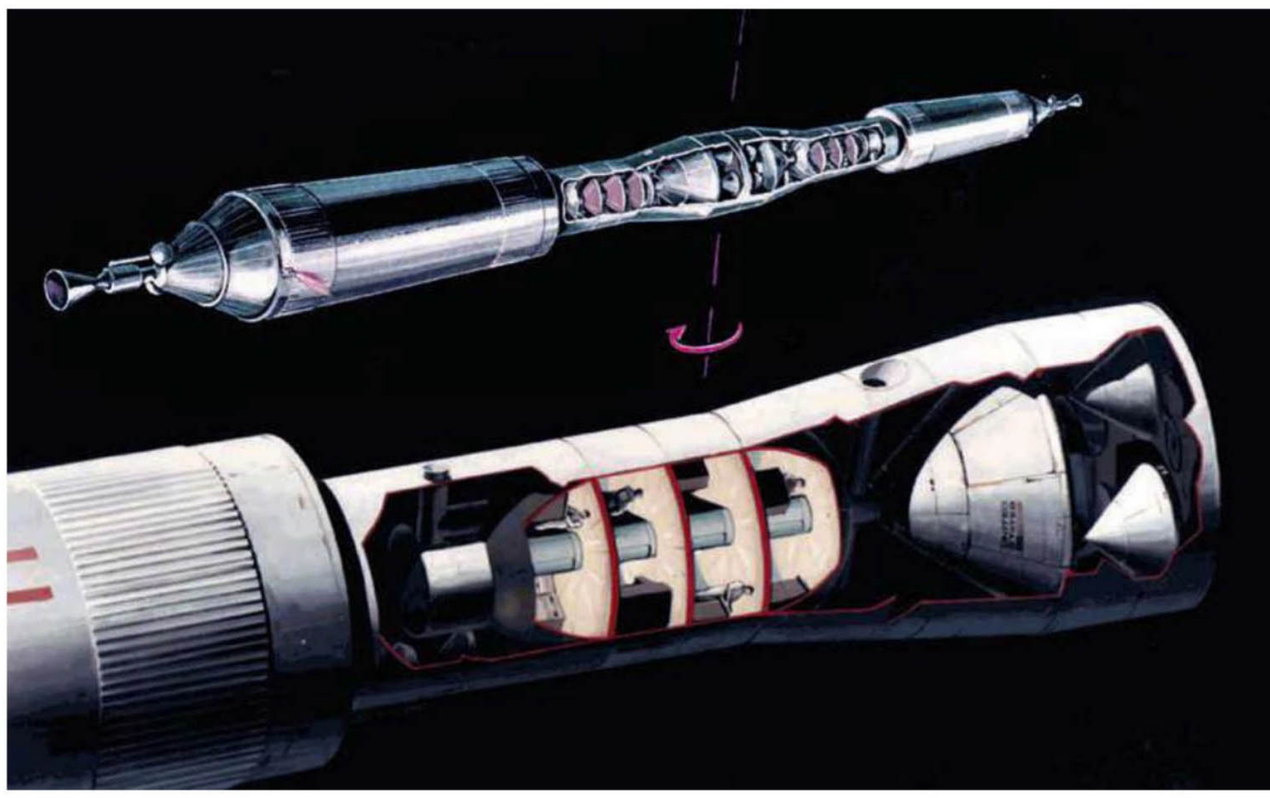
Wernher von Braun led the German rocket programme from the mid-1930s until the end of the war in 1945, before moving to the United States to help build America's. His engineering genius underpinned the giant Saturn rockets that took humans to the Moon and his management skills helped mobilise a team to achieve Kennedy's Moon landing goal.

As Apollo wound down, von Braun moved to NASA headquarters, taking charge of long-range planning, but his ideas were far ahead of their time. Without national commitment to fund such ambitious plans, von Braun became disillusioned and left NASA in 1972 to work for a US aerospace company.

In 1973 he was diagnosed with kidney cancer, but he continued speaking at colleges and universities, eventually helping to found the National Space Society in 1975. Ill health caused him to retire in 1976 and he passed away in 1977, but not before being awarded the US National Medal of Science. Von Braun was frustrated to the end that he had not been able to realise his lifetime ambition of putting humans on Mars.

▲ Wernher von Braun in his office at the Marshall Space Flight Center in 1964





▲ **Above left: von Braun's proposed spacecraft was based around three reusable Nuclear Shuttles**

Above right: once en route to Mars the two spacecraft would link up and spin, generating artificial gravity for the astronauts within them

protective shroud. The two outer Nuclear Shuttle boost stages would detach after accelerating to escape velocity, returning to Earth orbit where they could be used again. The core stage would not be fired until decelerating into Mars orbit.

The weight of the Mars mission hardware was colossal. At 82m long, the assembled vehicle would weigh 726,180kg after assembly in Earth orbit and carry a crew of six. Von Braun wanted two ships to fly to Mars in convoy, one serving as safe haven for the crew of the second in the event that it became disabled on the way out or back. Each Nuclear Shuttle would be 48.7m long, 10m in diameter and weigh 210,000kg. After the outer booster stages had been jettisoned, the weight of the stack would be reduced to 306,180kg.

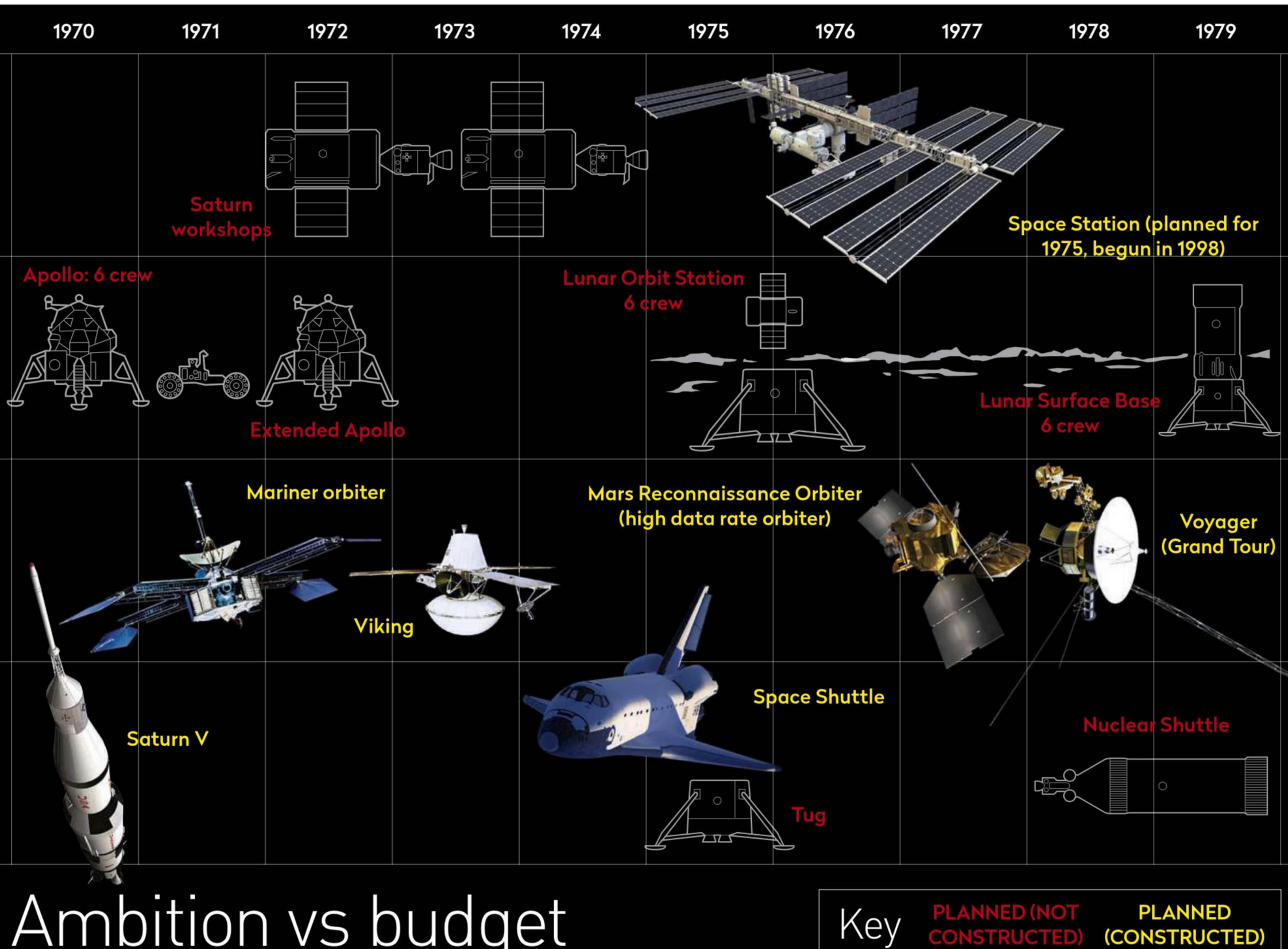
Nine months in space

The concept of reusable nuclear rocket stages was novel for the time. Much as today's SpaceX Falcon 9 core stages retain sufficient fuel to return to launch site, including firing to slow down for landing, the Nuclear Shuttle boost stages would turn around and slow down to head back for Earth orbit. There they could be used again, after being refuelled by the winged Earth-orbit Space Shuttle.

Von Braun calculated it would take nine months to get to Mars, trading the time taken to reach the planet for a higher payload on the nuclear rocket stages. Uncertain as to whether humans could survive that long in weightlessness, he proposed mating the two Mission Modules together, nose-to-nose, creating a rigid structure 164m in length that would spin around a common centre for artificial gravity.

The longest space flight at the time had lasted barely two weeks, and there was already some indication of effects on the body such as a loss of calcium in the bones and muscle degradation. Nobody knew what the effects would be of a long trip: the three crew members who would not land on Mars would be weightless for 21 months.

During the nine-month flight between Earth and Mars the crew would have lived in a spacious habitat, a cylindrical section 7.7m in diameter and 12.7m in length, a pressurised volume incorporating four decks, with access to each via a central tunnel that could ▸



Ambition vs budget

Spacefaring nations still aspire to put boots on the Red Planet – yet astronauts have never made the perilous journey to Mars because space exploration has never received the necessary funds.

Von Braun's Integrated Program plan of 1969 would have required NASA's budget to double by 1974. As it was, NASA's budget was in decline and the Space Shuttle wasn't approved until January 1972, on a greatly reduced budget. Out went the Nuclear Shuttle, the space base and plans to return to the Moon, leaving only the Shuttle to begin operations in 1981. What it had hoped to develop in parallel NASA had to place in sequence, with the space station adapted as an international venture and only emerging in the 1990s.

At its peak in 1965, NASA received 4 per cent of the US federal budget. For years now, it has been barely above 0.4 per cent. Only thanks to international cooperation and investment by private entrepreneurs is the goal now in sight. Current plans for a return to the Moon are integral to creating a deep-space destination as a departure point for a new generation of astronauts.

MARSHALL SPACE FLIGHT CENTER/NASA, PAUL WOOTTON X 16, 3DSCULPTOR/ISTOCK/GETTY IMAGES, NERTHUZ/ISTOCK/GETTY IMAGES, NASA/JPL CALTECH X 2, NASA X 2

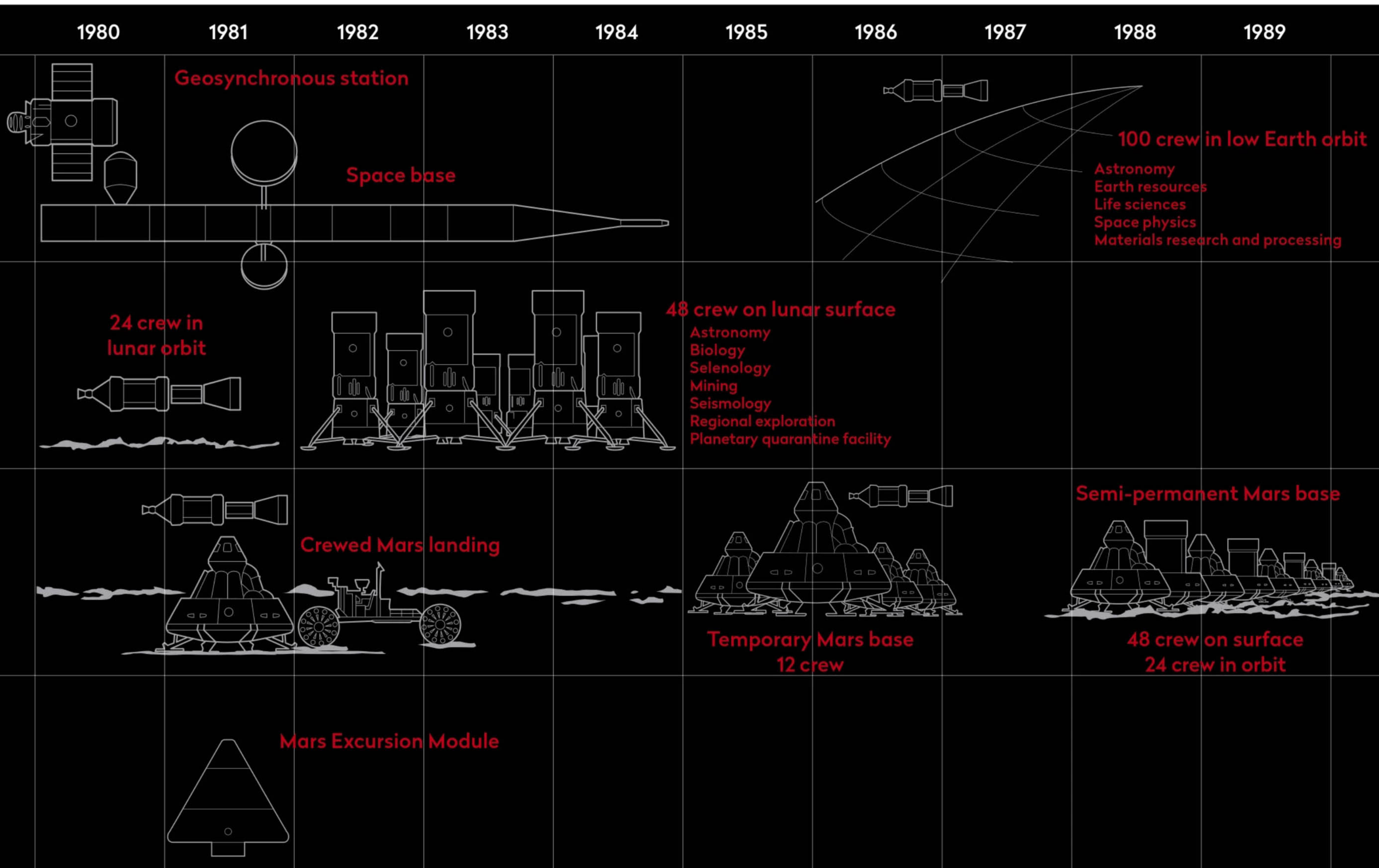
► serve as refuge in the event of a solar storm. The crew would have recorded and observed the physical state of the human body, conducting astrophysical observations and a variety of experiments.

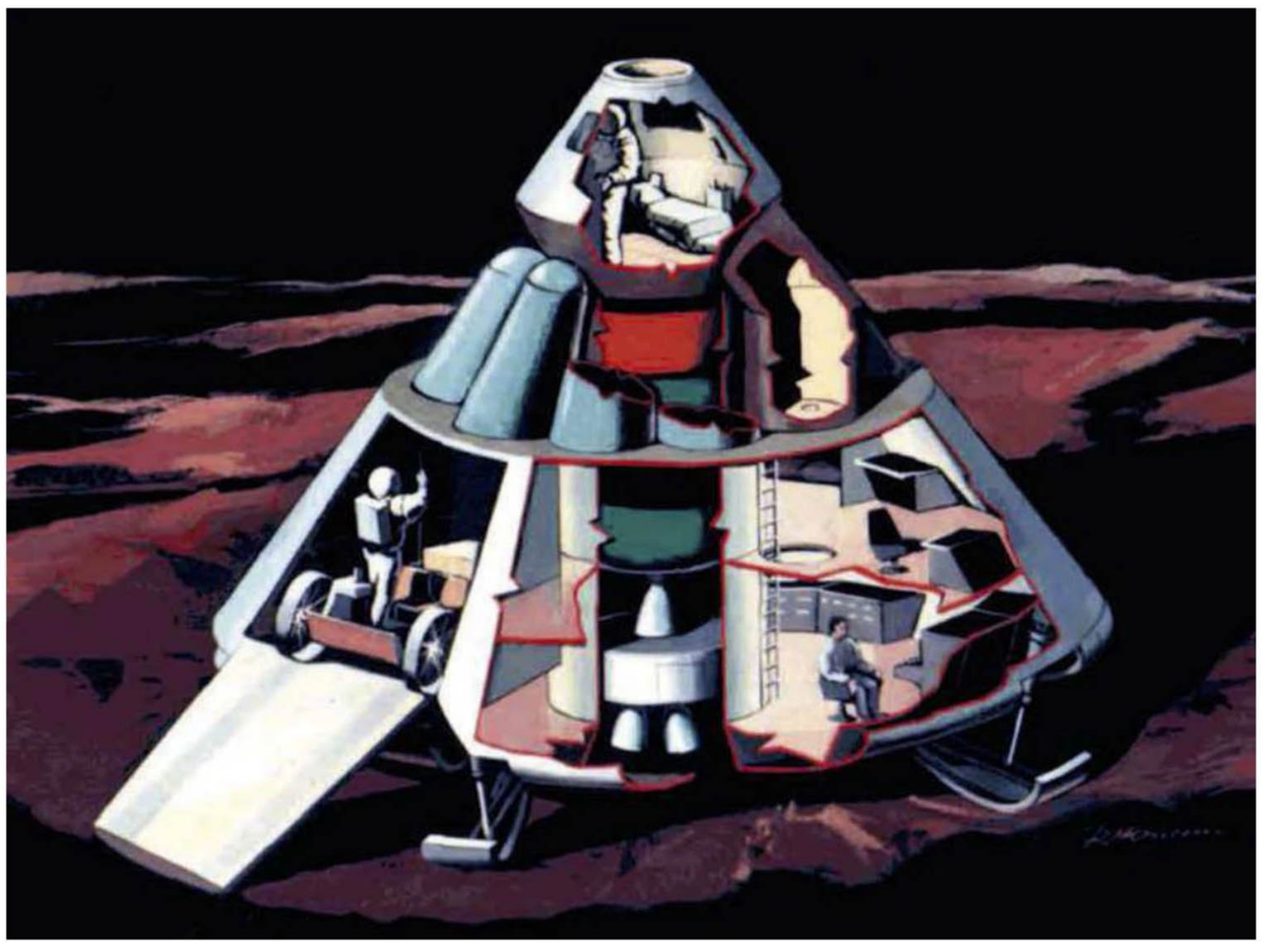
With Mars launch windows occurring at intervals of just over two years, von Braun proposed Earth departure on 12 November 1981, a date he felt was sufficiently far ahead to develop the necessary hardware at an affordable pace, with arrival in Mars orbit on 9 August 1982. The core Nuclear Shuttle stage would decelerate the combined stack and the crew would spend around 10 weeks in Mars orbit, sending probes to the surface that would extract materials and return them to the ship, analysed and cleared of any bacteria harmful to humans.

Then the three crew members would make the trip to the surface in the Mars Excursion Module. The cone-shaped module was capable of supporting three astronauts for 30-60 days and would have had a weight of 50,900kg before expending rocket propellant to decelerate to the surface. Some degree of atmospheric braking would have been possible, but parachutes and a braking rocket would also have been used. Various options were available for the size of the module, most being around 8.8m in height and 10m in diameter, with a landed weight of 37,000 kg.

Life on Mars

The Mars Excursion Module would have provided for crew comfort, access to the surface and a laboratory, although how much of that would have actually proved feasible is a moot point. After a month or two at the surface, the upper ascent section of the MEM would carry the crew back to the orbiting cluster.





▲ **While on the Martian surface, astronauts would be protected by the Mars Excursion Module**

There were no plans to establish a permanent base, but a small rover would have given the crew mobility on the Red Planet.

The Mars ships would have departed for home on 28 October 1982, but the return flight would have taken the crew via Venus on 28 February 1983. The inner planet's gravitational pull would shave off the ship's Earthbound velocity, reducing the speed of re-entry but also providing an opportunity to deploy probes to Earth's twin planet. It would be back in Earth orbit on 14 August 1983, to rendezvous with a space base which would have been established before the expedition began, with the crew returning through the atmosphere in a Space Shuttle after checks to verify they were free of Martian bugs.

Although logcial, the Mars mission plan was ultimately flawed: it relied on technology and hardware that had yet to be developed. The proposed Nuclear Shuttle, the Earth-orbiting space base and even the Space Shuttle were unique and without parallel or precedence. And there was no guarantee that those propositions would have been feasible.

Undertaking von Braun's plan would have required an ambitious expansion of NASA's resource base, not least money, and a national commitment that had waned and did not exist in 1969. Yet 50 years on, under Space Policy Directive 1, NASA is again planning to return to the Moon, possibly by 2024 and with a semi-permanent base by 2028. From there, von Braun's vision for Mars may be possible at last.

Dr David Baker worked on NASA's Apollo and Shuttle programme. He is an award-winning author and the editor of *Spaceflight* magazine

Photographing a lost VENUS PROBE

How amateur astronomer **Ralf Vandebergh** captured a spacecraft that became space junk on a forgotten orbit of Earth

Among millions of other items of space junk, a tiny failed Russian spacecraft is orbiting Earth – as Ralf Vandebergh and his camera discovered

▲ **An artist's impression of a Venera probe successfully landing on Venus**

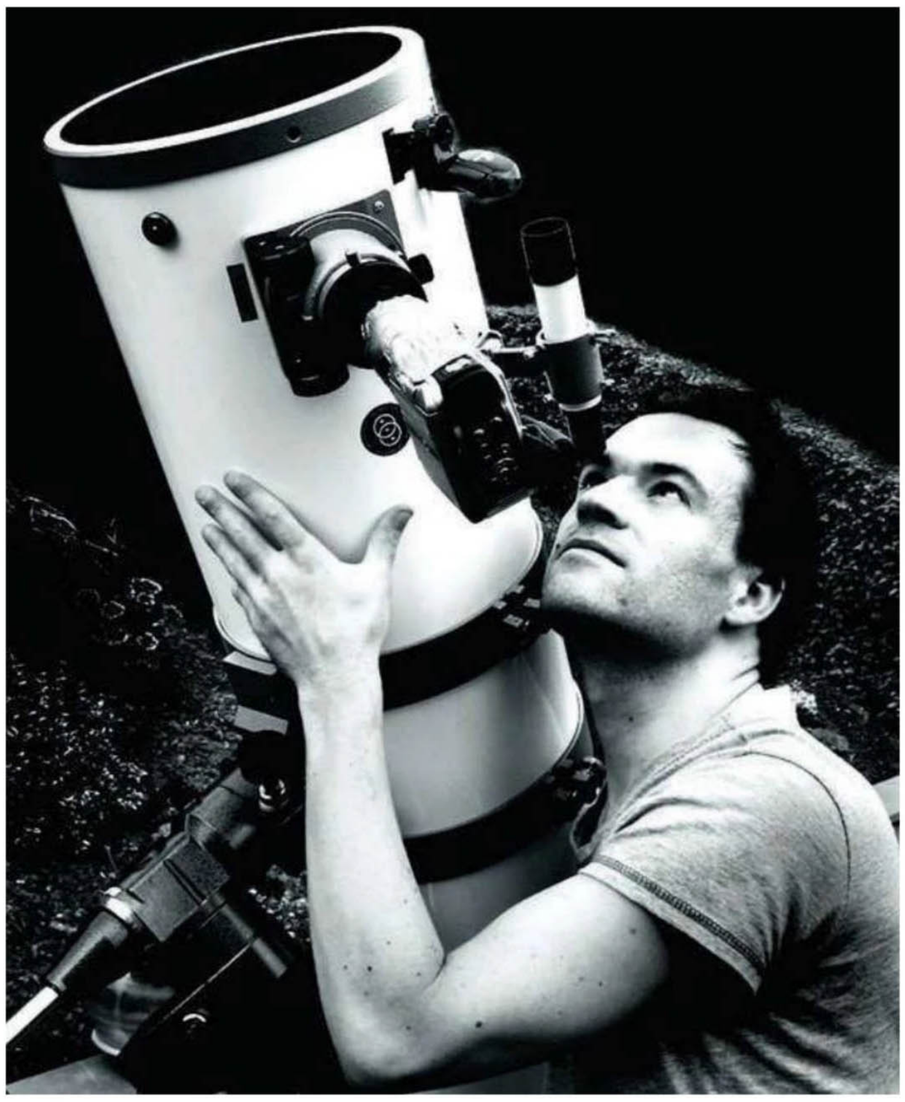
Ralf Vandebergh specialises in high resolution imaging of spacecraft from the ground and is a freelance spaceflight journalist

Around 2010, after years of observing planets and the International Space Station (ISS), I was looking for a new challenge – hunting down satellites in low-Earth orbit. While out watching different satellites pass over my observing location in the Netherlands, I spotted an extremely fast-moving object with 7x50 binoculars, and searched on my satellite list for what the object could be. There are many satellites and space debris items in the night sky, ranging from weather satellites to spying spaceplanes, but this particular object seemed even more interesting.

It turned out to be a remnant of an old planetary probe that was intended to visit Venus, one of the Soviet Union's Venera programme which failed while still in low-Earth orbit. These spacecraft were launched between 1961 and 1984, studying the planet and even landing on its surface, but not all of the craft made it. Those that failed while still in Earth orbit were given the designation Cosmos – and I had found Cosmos 482.

Knowing that Cosmos 482 was an intended Venus probe, or at least a part of one, piqued my interest. I had to try capturing it with the imaging equipment I used for the ISS. To have any chance of success I needed to wait until Cosmos 482 reached its perigee point, where it passes closest to the ground.

Before the digital era, it was completely impossible to obtain high resolution images of orbiting satellites through telescopes, due mainly to the insensitivity of photographic emulsions used at that time. The invention of the charge-coupled device (CCD)



▲ **The author with his imaging setup, taken around the start of the Cosmos 482 campaign in 2011**

has made it possible to work with extremely short exposure times and small imaging scales, required to freeze the movement of objects at high angular speeds. My setup consisted of an Orion Optics 10-inch aperture Newtonian reflector on an equatorial mount with an ordinary JVC camcorder. The video camera is attached to an eyepiece, so I can quickly ▸

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X 2, STOCKTREK IMAGES INC/ALAMY STOCK PHOTO

A history of failure

Like all space junk, Cosmos 482's story can be mapped out

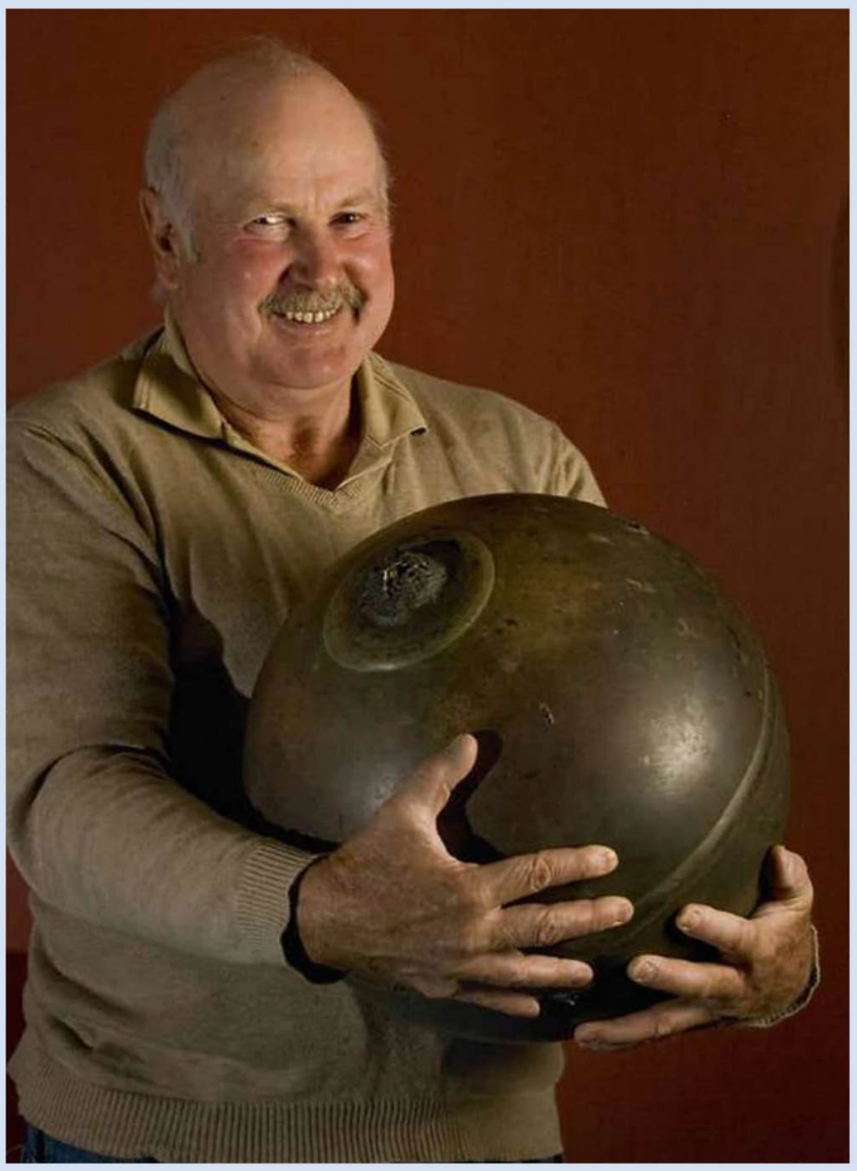
The Venera programme was a series of probes built to study Venus both from orbit and on its surface. Venera 7 made the first successful landing in 1970. The probes were launched in pairs, as rocket launches frequently failed back then. The move proved wise, as when Venera 8 launched in 1972, its sister probe exploded while in Earth orbit.

After the failure, different objects were spotted in Earth orbit, the largest of which became known as Cosmos 482, which is the part I imaged.

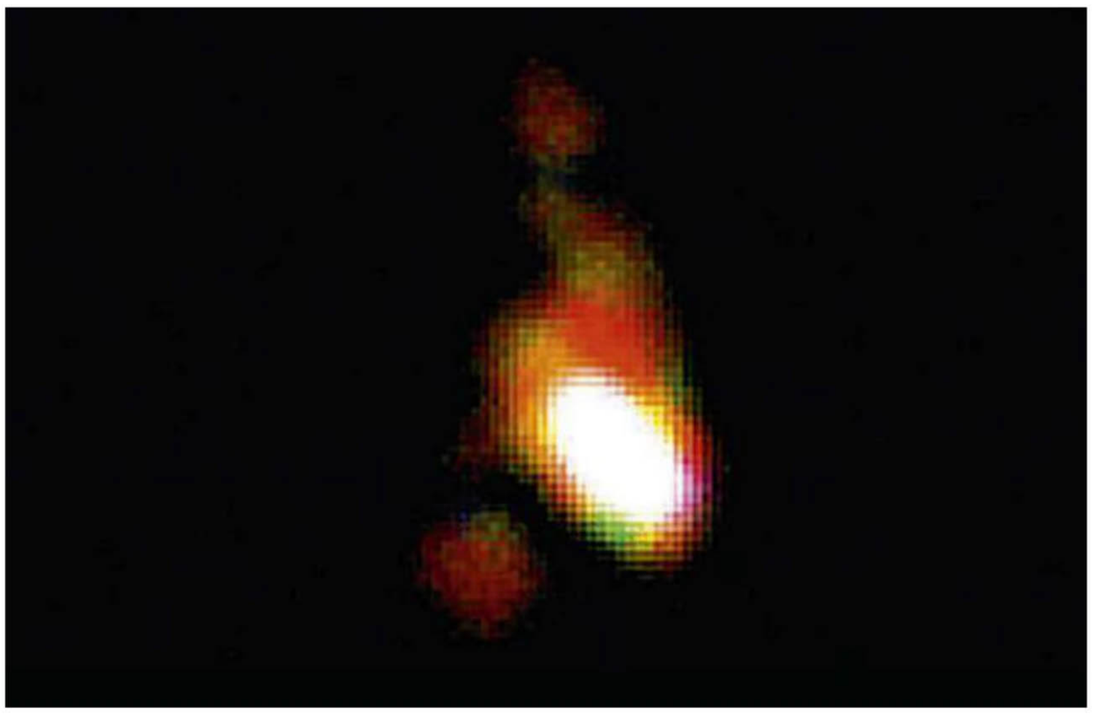
Cosmos 482 is a prime example of space junk – old spacecraft parts that are increasingly cluttering up low-Earth orbit. In the years after the explosion, much of the spacecraft fell back to Earth. Some parts took just 48 hours to re-enter Earth's atmosphere. In 1978, the fuel tanks fell near Ashburton, New Zealand and were called 'space balls' due to their shape.

The remaining part of the spacecraft is expected to re-enter the Earth's atmosphere sometime in the next 15 years, perhaps as early as late 2019. As this is thought to be the landing capsule, which was constructed to withstand the extreme conditions of Venus, the capsule could survive its return to Earth. This is why ground-based imaging of objects like Cosmos 482 can be useful: to find out what the actual condition of the object is.

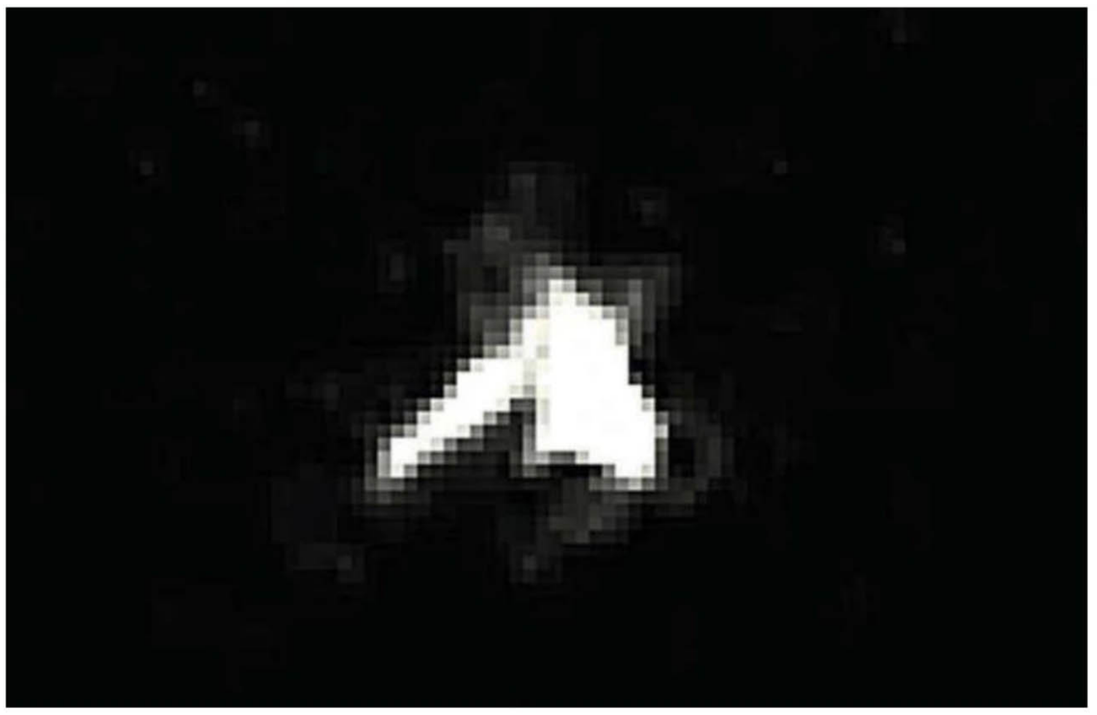
But space debris is not only a threat for people on the ground – orbiting debris can be dangerous for spacecraft in low Earth orbit too. In April 2011, debris from a weather satellite that was intentionally destroyed by a Chinese anti-satellite missile test, passed only 6km from the International Space Station, risking the lives of those on the station.



▲ New Zealand farmer Denis O'Sullivan shows off his 'space ball', a fuel tank from the Russian probe Cosmos 482 which landed in his turnip field in 1972



▲ The first image of Cosmos 482, taken on 1 August 2011, reveals a bright compact element and a fainter, elongated one



▲ Cosmos 482 imaged on 26 June 2014 during a different pass. Again, we see comparable details, including an elongated element

JOHN KIRK-ANDERSON, RALF VANDEBERGH X 3, DOTTEDHIPPO/ISTOCK/GETTY IMAGES, UNIVERSAL IMAGES GROUP NORTH AMERICA LLC/ALAMY STOCK PHOTO

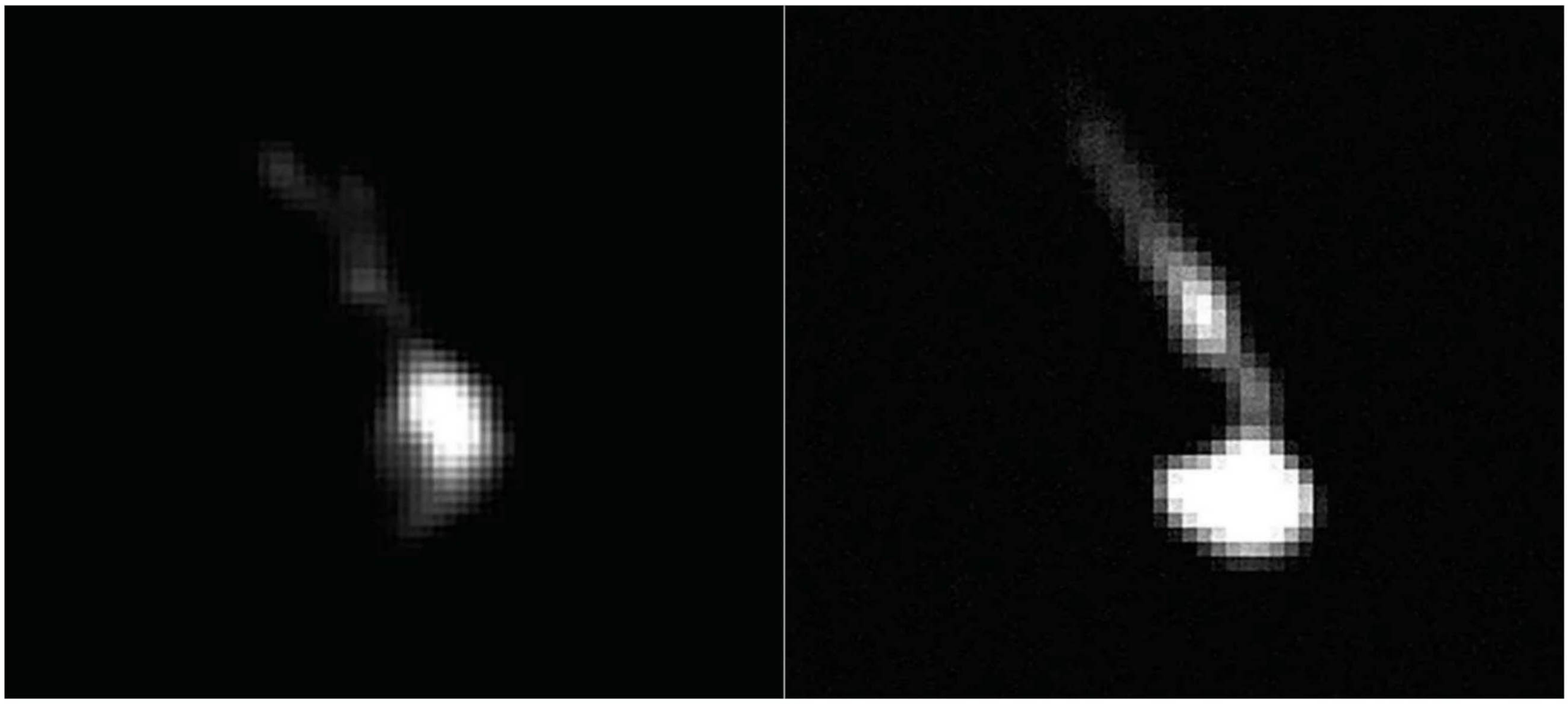
► put it into place and be ready to image in seconds. Initially the camera was rough focused at a fixed point, but then I would precise focus on a star close to the path of the object shortly before it approached.

At the ready

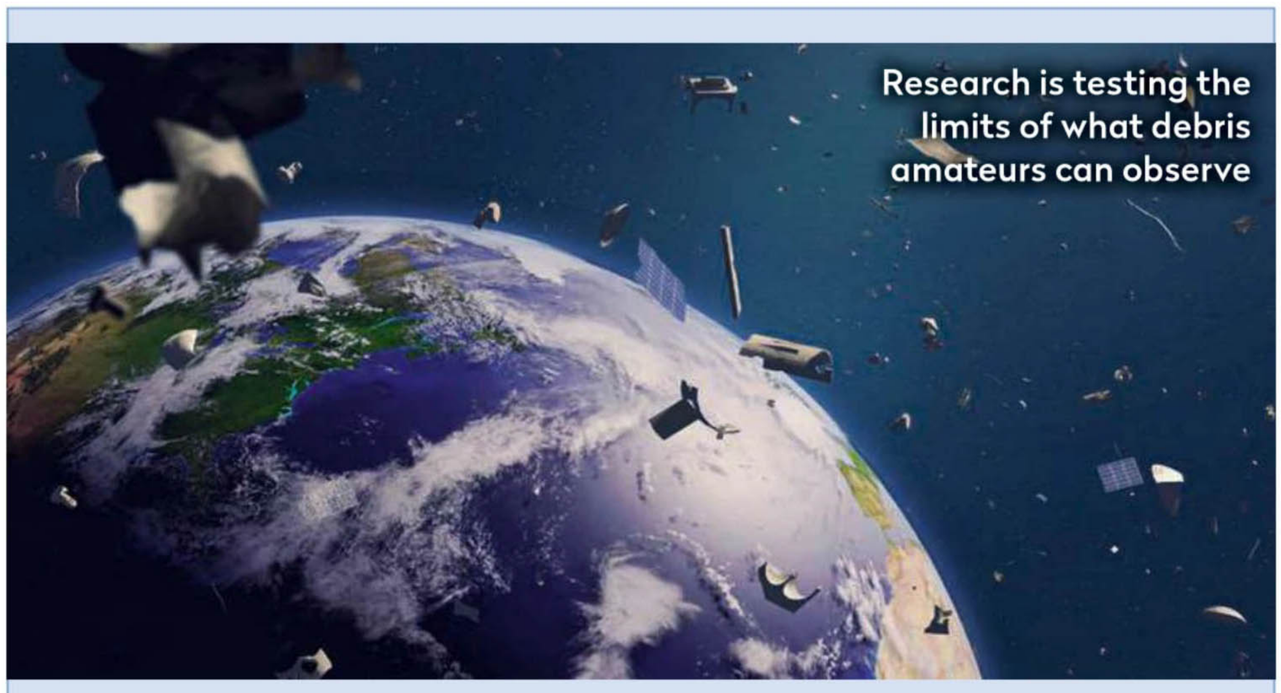
To obtain an image of the ISS or another satellite, I manually track the spacecraft using a small tracking scope and keep the object centred in the crosshairs while recording everything with the camcorder. This is much cheaper than automatic tracking, doesn't require computer software and means I can be ready to capture an image in just a few seconds.

The problem with small objects like Cosmos 482 is they're mostly not visible with the naked eye, making tracking them a challenge. With the ISS you can see it with the naked eye and point the tracking scope in the right place, but with small objects I find reference stars along the path of the orbiting object across the sky. Keeping those stars in the field, I then wait for the satellite to appear and then hang on to it as soon as it does. If all works well, the resulting video will have at least a few frames with the satellite. This requires a well-adjusted tracking scope and experience, but if you get it right the results can be spectacular.

In August 2011, I managed to take my first images of Cosmos 482. These were the first high-resolution images ever taken of this object – a very exciting thing to do. Only part of the Cosmos 482 spacecraft remains in orbit, and one reason I took these images



▲ The author has grabbed frames from the video footage he took on 26 June 2014, to produce these two images which, he speculates, could show the bright, spherical shape of the Venera landing capsule. The elongated, somewhat fainter tail is mysterious, but it's possible that this might be the parachute of the lander which was deployed (partially) when the capsule separated from the spacecraft



Amateurs track space junk

Astronomers are helping to track debris from their back gardens

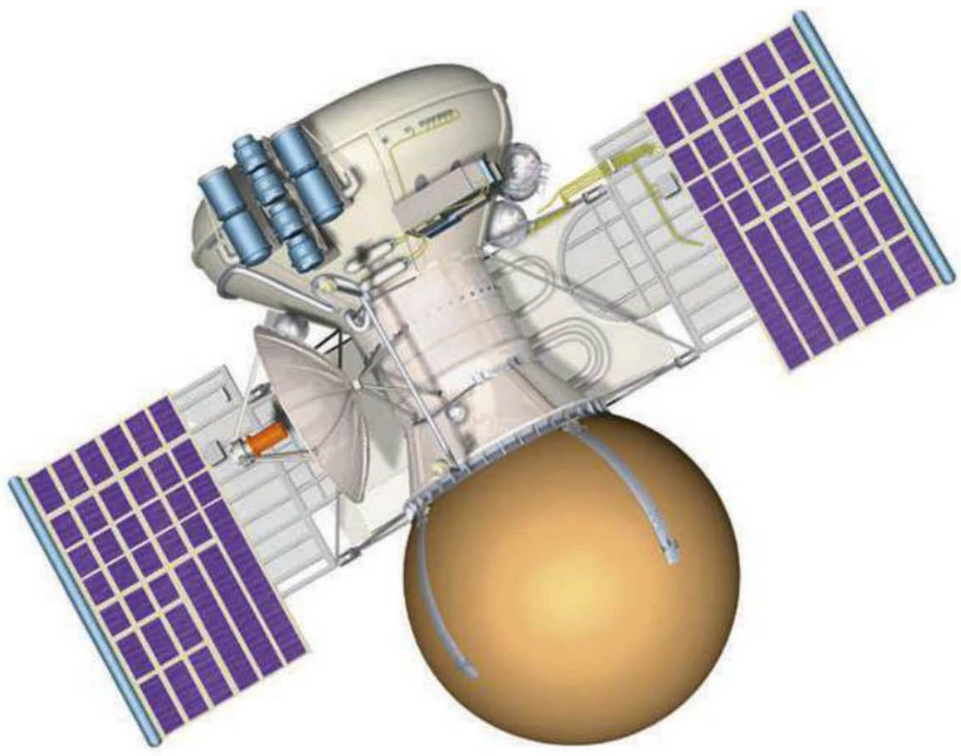
Space debris is a big problem. In the UK, the Defence Science and Technology Laboratory (Dstl) has been leading efforts to mount a mission that will remove dead satellites from orbit. Before they can do that though, Dstl needs to accurately know where they are.

"Professional astronomical facilities tend to be expensive, and state-of-the-art facilities are few and far between," says Will Feline from Dstl. "Amateur astronomers, however, are more widespread and use equipment which is by definition much cheaper."

To test if amateurs could help track space debris, Dstl worked with the Basingstoke Astronomical Society (BAS) on Project Argus – an initiative to find the limits of what amateur equipment could do in detecting and tracking orbiting space junk.

The group used standard DSLRs and CCD cameras to track objects in space, using GPS trackers to accurately time-code their observations. Accurate times are vital for calculating orbital positions, but the group found the basic software unsatisfactory and so wrote their own, which is accurate to 20 milliseconds.

"After months of observations we determined that trailing objects with magnitudes between +7.0 and +9.0, or so could be detected with short exposures on DSLR and CCD cameras," says Trevor Gainey, chair of the BAS. Dstl is currently analysing BAS's hard won data, to see how amateur astronomers could help fight space junk in the future.



▲ This illustration of a Venera probe clearly shows the spherical section which housed the lander craft

was to try and find out what part this is. Because you don't know what to expect, there is the excitement about whether you can reveal anything.

The results were surprising. The images showed an elongated shape with a visible bright blob near its centre, flanked by two fainter elements. As the image was still quite blurry at this resolution, I had to remove imaging and tracking errors – such as disturbances from air turbulence or exposures that were too long.

I retook the images in 2014, and confirmed much of the detail, but finding out exactly what parts of the spacecraft are still in orbit has been difficult. That's why I waited until now to publish the results. This perhaps goes against the spirit of astrophotography today: data gets old quickly and everything seems to be posted in real time. But these images of Cosmos 482 demonstrate that it is still possible for amateurs to do new things, and that an element of patience can pay off where long-duration projects are involved.

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Summer stargazing FOR KIDS

Ruth Perkins takes a look at some of the best ways to introduce kids to the rewarding hobby of astronomy

Stargazing with children is a joy if you tackle it in the right way. Here is our quick guide to making the most of it now school's out for summer. It's never too early to start exploring the night sky. Try a mix of activities and don't worry if things don't go the way you planned.

Let your child lead the way and listen to their questions. Never be afraid to answer with "I don't know, but that's a brilliant question. Let's look it up together." If they're struggling, prompt their interest by asking them about what they can see, or what they already know. Build on their curiosity, but don't overwhelm them with too much information.

Everyone learns better through play, so have fun! ▸

KONTREC/ISTOCK/GETTY IMAGES

Bright ideas: you'll be surprised what facts you discover when you answer the questions raised by children about the night sky

Choose the right equipment

Having the right accesssories makes a big difference. Help kids get used to handling a rotating star map as soon as they are able to. A red head torch can reassure children if they are nervous of the dark, and take a laser pointer to help them point at the sky but make sure they know it's dangerous to point it at anyone. Astronomy apps are useful and are an appealing tool for some children.

Binoculars are the best choice for most beginner stargazers, and kids will get more general use out of them. Look for lightweight models and check the smallest eye width setting fits them. Get them into the habit of always using the neck strap.

A refractor telescope is a good, as it is low maintenance and is easy to use. Try borrowing or renting a telescope before you buy. Is there a local astronomy group that would welcome you all?

▲ Laser pointers can be great observational aids, just make sure they are used responsibly

Teach them what they're looking at

If you can't get outside you can use a tennis ball and a torch to demonstrate the phases of the Moon or an eclipse. Hold the torch and explain you represent the Sun. Ask them to hold the tennis ball above their heads and look at the shape of the shadow on the ball as they turn slowly on the spot. Another activity, which shows scale, involves a basketball and a tennis ball. Ask what the tennis ball represents if the basketball is Earth. Next, give them the tennis ball Moon and see how far away they think they need to stand from the basketball (on this scale it's about 7.5m). By shining a light on a tennis ball you can also show how an eclipse works, as the Moon casts its shadow on Earth.

Look at bright targets

"What is the brightest thing you can see in the sky tonight?" It is easiest to start by looking for bright targets such as the Moon or planets. Do they notice the red glow from Mars? Have they seen the Moon during the day?

Try asking them how you might measure the change in the apparent shape of the Moon over time. They could take a picture or draw the Moon with glow in-the-dark paint once a week.

A verse of Twinkle Twinkle Little Star leads nicely into a discussion about why planets don't twinkle as much. The stars, being much further away and pinpoints of light, appear to flicker because of the way their light is affected by our atmosphere. The planets, which are much closer and reflect the light from the Sun, aren't affected as much.

Think about the practicalities

The first consideration should be to get comfortable. Try bringing a mat to lie on or camping chairs, then allow time to adjust to the dark. What can they see; are there any patterns? Encourage your young stargazer to practise looking with one eye. Ask if they would like you to help cover one eye with a hand, or bring a toy eye patch just in case. They could use a 'dark sky tube' by rolling up a piece of black card into a cylinder big enough to fit over their eye. It'll also help to combat inner city light pollution.

Have a step stool for them if you are observing with a telescope. Let them move the scope to find something bright in the sky, then show them how

▼ Exercises such as painting the lunar crescent can help children to understand the lunar cycle

PHOTONONSTOP/ALAMY STOCK PHOTO, STEVE MARSH X 2, INES BAZDAR/ALAMY STOCK PHOTO, VLADANS/ISTOCK/GETTYIMAGES, ILLUSTRATION BY PAUL WOOTTON


Binoculars are lightweight, easy to use and a perfect entry point for children


Teach kids about an eclipse with a tennis ball and a torch

the picture they see changes with just a little nudge of a hand. Explain that it's best not to touch the equipment once it's pointing at a particular object. If you hold a child's hand while they're at the eyepiece it will help stop them grabbing at the eyepiece as well as giving them stability. Have patience and take time to enjoy this special experience.

Consider the time of year

Remember to bring layers when you are venturing outside, as it can be cold at night even in summer. Bug spray, snacks and drinks are all recommended. Keep an eye on the weather and have a back-up plan should clouds appear or rain sets in. Check when Mercury, Venus, Mars, Jupiter, and Saturn will be visible and avoid trying to observe the fainter planets during the brightness of a full Moon.

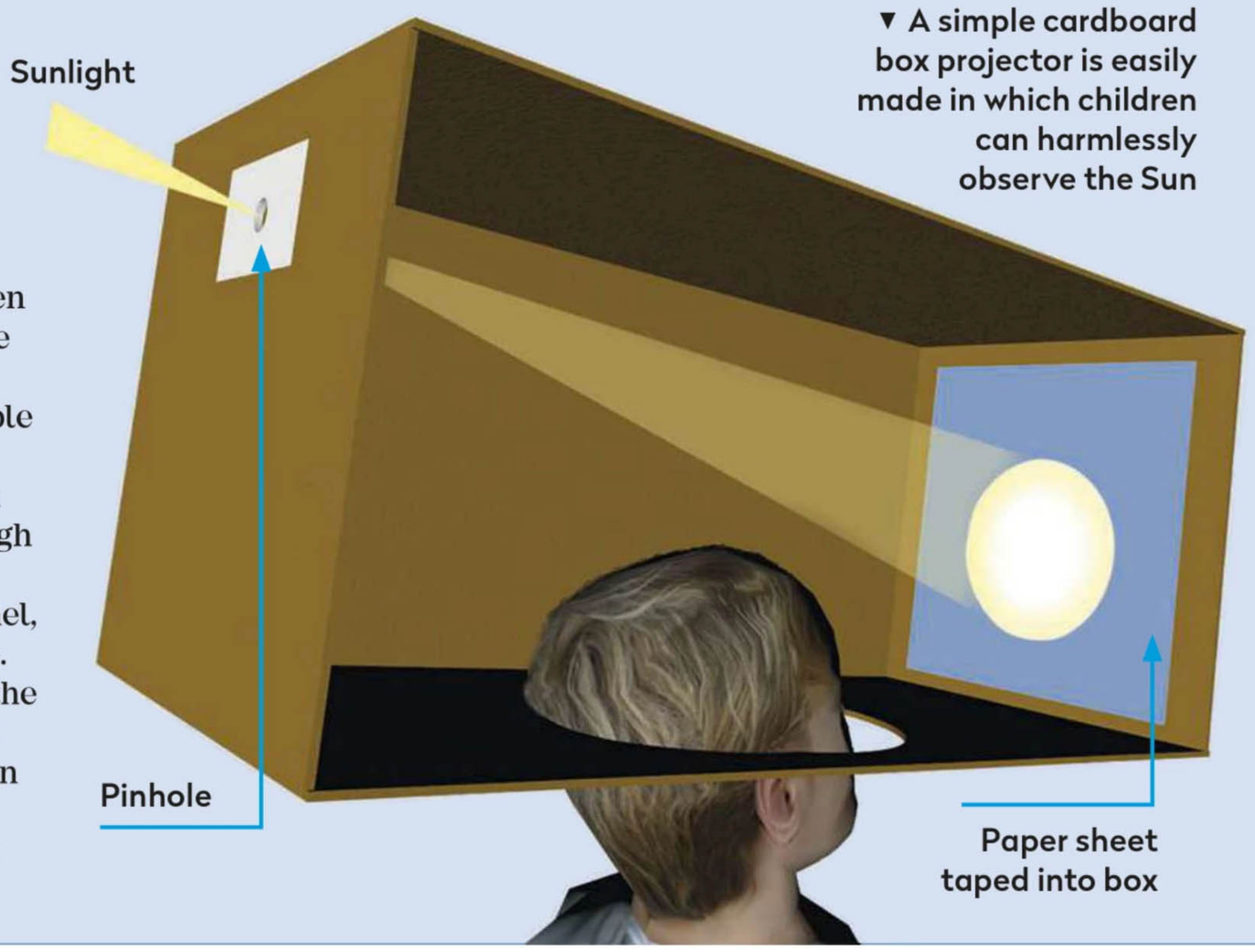
Ruth Perkins has been working for Science Made Simple and enthusing children about science for over 10 years

Find a good place to observe

Start your observations in a familiar place such as a back garden or local park. Once they're comfortable with that, start venturing further afield. Streetlights affect night vision so get as far away from them as possible. There are now 12 International Dark Sky Places across the UK and Ireland. Seek out one of these wonderful areas for the best night skies protected from light pollution. But if you can't get out that far remember it's still possible to see the Moon, some planets, and the brightest stars from a city if it's a clear night. Get out there and have some fun!

Safely observe the Sun

Summer is a great time to try solar observing. Children are taught from a young age not to look directly at the Sun, but remind them of this, particularly if you are using magnification. Special eye protection is available but the safest way for them to observe is using projection. Take a long fully enclosed cardboard box and make a hole big enough to stick their head through on one of the longest panels. Place a sheet of white paper over the end they will face. On the opposite panel, behind where their head will be, make a high pinhole. They will need to stand so they are facing away from the Sun, but the pinhole is pointing at it. The light should travel over their head onto the paper. A solar filter can be used with binoculars or a scope to project onto a white sheet, but never leave that setup unattended in case anyone tries to look through the eyepiece.



▼ A simple cardboard box projector is easily made in which children can harmlessly observe the Sun

The fundamentals of astronomy for beginners

EXPLAINER

All about the astronomers' eclipse

An armchair guide to the only glimpse of totality in 2019, taking place this month

AARSTUDIO/ISTOCK/GETTY IMAGES, ESO/H.ZODET

Seeing a total solar eclipse should be top of everyone's bucket list. There's one occurring this month on 2 July, but it will only be visible from the Pacific and South America. Not exactly down the road, is it? If you can't make it don't worry, there's another in the same location in around 18 months. Meanwhile, let's be armchair enthusiasts and get the lowdown on the summer's dramatic event.

The Sun and Moon appear the same size in the sky: a result of the Sun's diameter being 400 times greater than the Moon but also, serendipitously, 400 times farther away. Solar eclipses arise when the Sun, Moon and Earth are nearly aligned (known as syzygy) during a new Moon, when our satellite is close to the ecliptic (the imaginary circle in the sky representing the Sun's apparent path throughout the year).

If the Moon's orbit was perfectly circular and if the Moon was a little closer in the same orbital plane, we would enjoy total solar eclipses every new Moon. But since its orbit is tilted by more than 5° relative to Earth's orbit around the Sun, our satellite typically passes north or south of our star.

When the Moon completely covers the Sun, it's a total eclipse, and when only part of our star is hidden, the result is a partial eclipse. Since the Moon's orbit isn't perfectly circular, when it's in syzygy but farther from Earth than its average orbital distance, it appears smaller than the Sun and is surrounded by a ring of sunlight: an annular eclipse. For totality, the Moon must be close enough to the ecliptic plane during its new Moon phase – as it will be on 2 July this year.

The result will be two lunar shadows. The inner one, the umbra, is cone-shaped, darker and narrows towards Earth. The outer shadow, or penumbra, is less

▲ During a total eclipse, the Moon's full shadow is typically 160km wide and stretches across Earth for thousands of miles

▲ Anywhere within the thick grey line will experience totality on 2 July. The thin centre line is where it's longest

dark, diverges towards Earth and covers about half its daylight hemisphere. Anyone standing within the outer shadow will see a partial eclipse.

Thrill of totality

But to experience the biggest thrill – totality – you must be within the umbra, the Moon's full shadow, where it strikes Earth. This dark corridor, or 'path of totality', is typically 160km wide, thousands of miles long and, since Earth and the Moon are in motion, tracks west to east across the planet. This year it will start at 18:02 UT in the Pacific, 1,900km east of New Zealand's North Island, the umbral shadow making landfall on Oeno Island, an uninhabited coral atoll, at 18:24 UT. Totality here lasts for 2 minutes 23 seconds. Avid umbraphiles will be cruising in the South Pacific, 1,080km north of Easter Island, because this is where the greatest eclipse occurs at 19:24 UT. With the Moon just three days shy of closest approach to Earth (perigee), anyone afloat in this region will, weather-permitting, see 4 minutes 33 seconds of totality across a 200km-wide path.

Having crossed a further 4,000km of ocean, at 20.39 UT totality's path then makes landfall on the Chilean coast, 50km north of La Serena. Here, people will watch the Moon's first 'bite' of the solar disc, then the Moon will cover the Sun, resulting in 2 minutes 17 seconds of stunning totality. Temperatures fall, the sky darkens, wildlife quietens and the Sun's outer atmosphere, or corona, blazes forth. However, being coastal, La Serena could be cloudy and subject to fog. Further inland the Sun, 14° above the northwestern horizon, may reveal pink jets of gas, or prominences, leaping from its outer edge.

The central shadow then tracks southeast to the Andean foothills. The world's first international Dark Sky Sanctuary, this arid mountain landscape affords high elevation, dry air and clear skies. Little wonder it's home to the European Southern Observatory at La Silla, the Cerro Tololo Inter-American Observatory, Gemini South and the Large Synoptic Survey Telescope. This is stargazing mecca and eclipse heaven.

Once past the Andes, and with the Sun's altitude below 10°, the umbra whizzes across Argentina at 26,000 km/h. Anyone in San Juan or Cordoba will enjoy at least two minutes of totality, as will those on top of buildings at sunset in the capital Buenos Aires. But with our star a challenging 1° above the horizon, and chaotic local traffic, it's best to avoid this site.

At 20:43 UT, the full Sun returns and the lunar shadow lifts away from Earth. Its 11,200km-long track will have swept across just over a quarter of Earth's surface. For professional or amateur astronomers and diehard eclipse-chasers, armchair or otherwise, it's guaranteed to put on an amazing show.

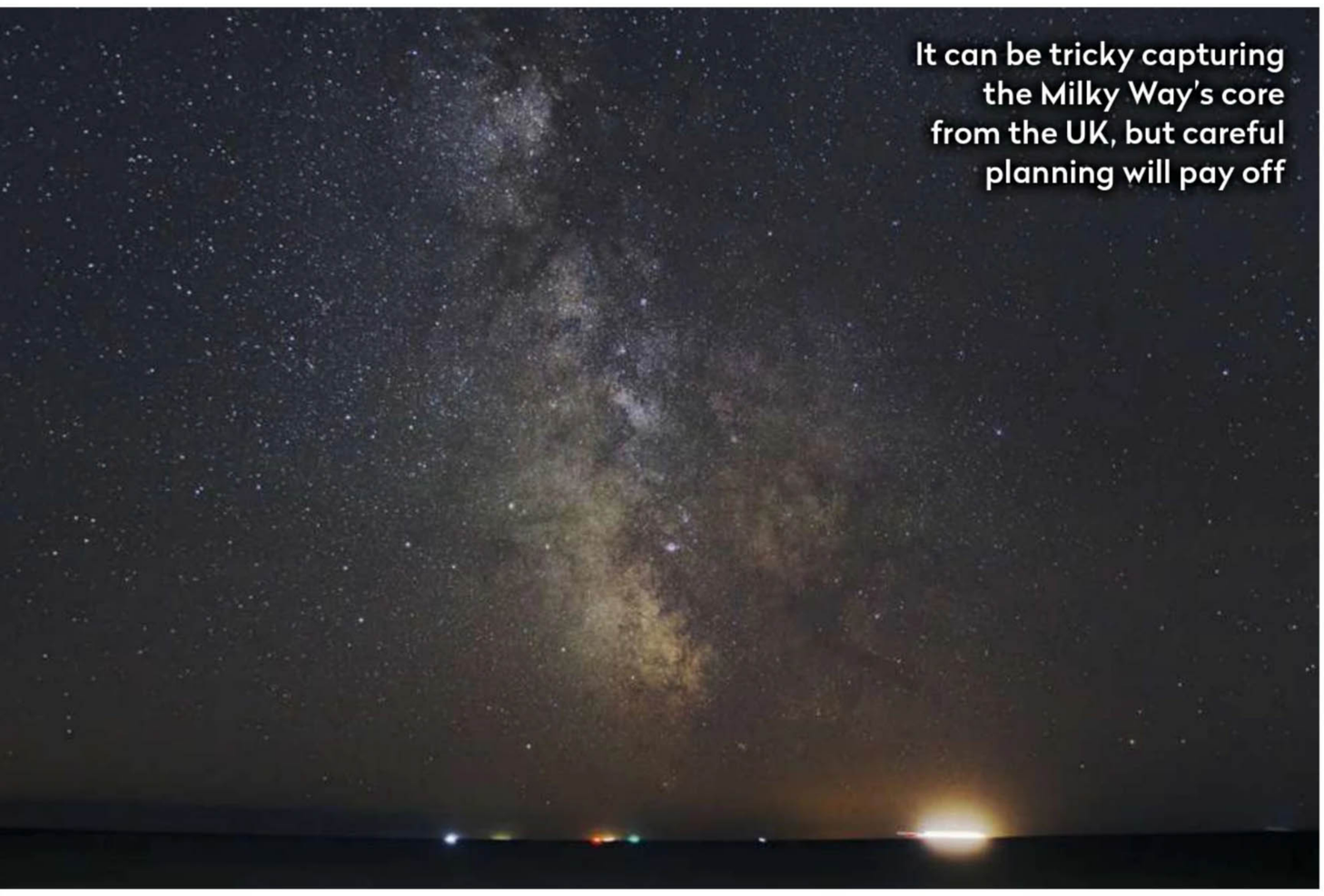
If you can't make it to see the eclipse in person, you can watch it live online at **www.skyatnightmagazine.com/space-science/stream-july-eclipse**

Jane Green is an astronomer, presenter and author of the *Haynes Astronomy Manual*

▼ Staff and visitors at ESO's La Silla Observatory will be in the path of totality

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE



It can be tricky capturing the Milky Way's core from the UK, but careful planning will pay off

The best tips for imaging the Milky Way's core

How to capture the glorious spectacle of our Galaxy

The Milky Way is an impressive sight if you have dark skies, and capturing a photograph of its celestial splendour is high on the bucket list for many astrophotographers. Fortunately, the task isn't too arduous and the bright portion running through Cygnus that sits overhead during the summer months will register on digital camera sensors without too much of a problem given dark skies. A wide-angle lens, near to being fully open (low f/number) and a mid- to high-range ISO should get the job done with just a few seconds exposure.

The core of the Milky Way is the part which looks brightest. Unfortunately, from the UK the core is challenging because it never fully clears the southern horizon. We have to image it through low horizon murk and this diminishes its impact somewhat.

When it's higher in the sky, seen from a dark sky location at more southerly latitudes, the core really is stunning. From locations where it is able to reach a decent altitude the core is capable of casting shadows.

Unless you're prepared to up sticks and take a trip further south, you'll have to employ a few tricks to obtain the best possible image. First is patience and timing; you'll need a sky which is as dark as it can be. This means waiting for a good clear period with no high altitude mist. This in turn will need to coincide with a night when there is no Moon present. Timing is also important for the core's sky position: waiting until it is due south will present it at its highest altitude. This will give you the best potential for the clearest view. But you may need to balance this against the twilight, which can be troublesome at this time of year.

Balancing all of these factors can be difficult and compromises often have to be made. Our recommendation would be to attempt your shot towards the end of July after the fuller phases of the Moon no longer affect the sky. The Milky Way's core will be slightly past south in the darkest part of the night from 24 July onward. Conditions remain favourable until the end of the first week in August. A similar period from 24 August through to the first week of September should also work.

Switching your camera to a high ISO will allow you to keep the shutter speed fast enough to take photos without having to use a tracking mount. A static tripod makes a perfectly fine base as long as you obey the 500 rule. This is simply to divide 500 by the focal length of the attached lens to get the number of seconds of exposure you can go to without stars appearing to trail due to the rotation of Earth.

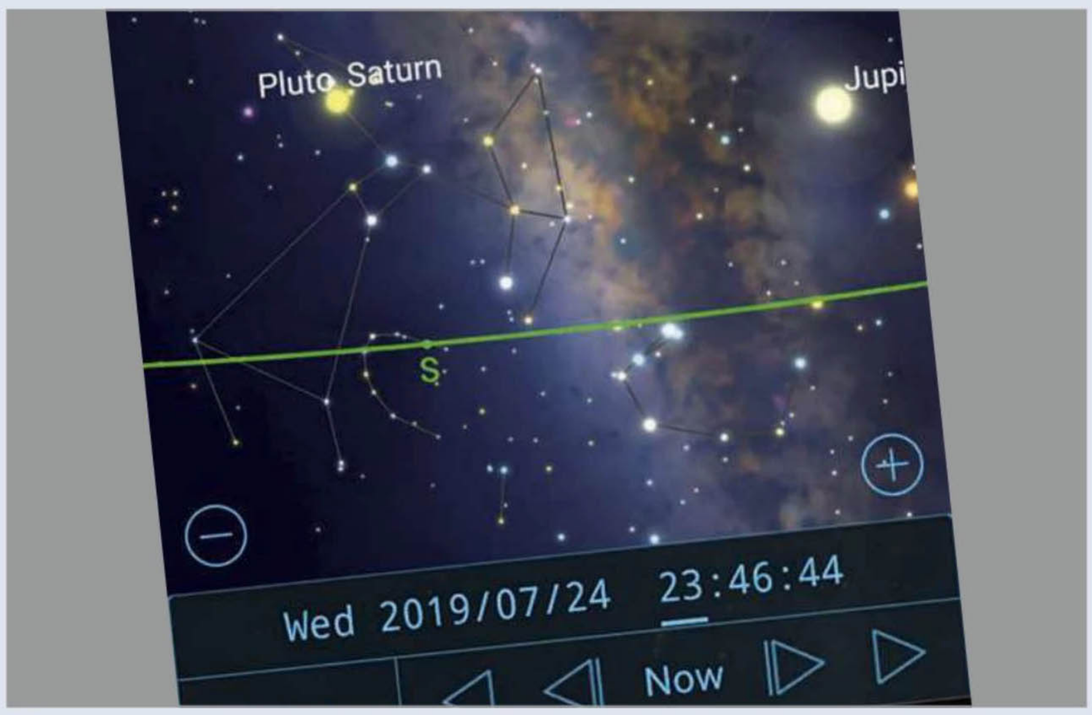
The higher the ISO the more noise, or unwanted artefacts, you'll get on your image frames. To use lower ISO settings you'll need a tracking mount. Here the problem reverses because of the horizon in your images. As the mount tracks the stars, the horizon will slowly appear to tilt in your shots. This only becomes an issue if you intend to stack a number of images caught over an extended time of several minutes.

Recommended equipment: digital camera, tracking mount, remote shutter release

Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

✉ **Send your images to:**
gallery@skyatnightmagazine.com

ALL PICTURES: PETE LAWRENCE



STEP 1

Timing and altitude are critical, but optimum conditions may not be achievable. Use a planetarium program or app to find your time of local astronomical (true) darkness. In the middle of the year you may not be able to experience this, so use nautical twilight. Determine the darkest period for different dates.

STEP 2

Plan your shots so the Moon doesn't interfere. A waxing crescent Moon needs to set early enough to give you access to the darkest period of night (see Step 1). Similarly, a rising waning Moon needs to remain below the horizon long enough to avoid your shot. Get moonset and rise times from a planetarium program or app.

STEP 3

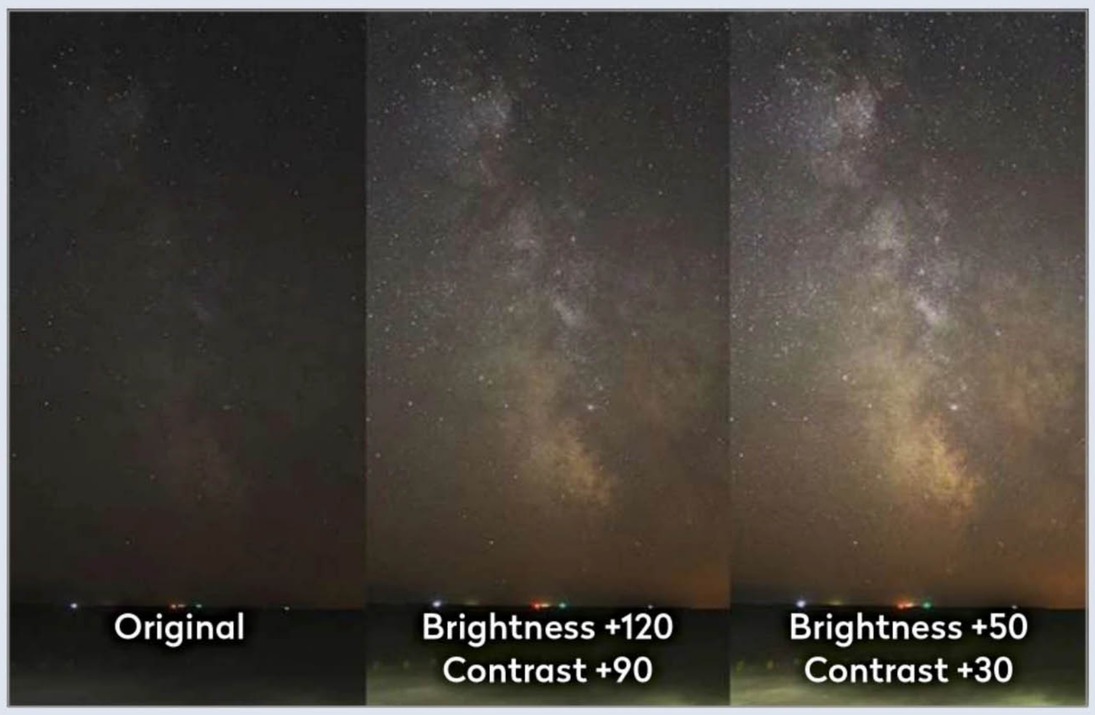
Choose a site which is dark and away from any stray lights or sky glow from distant lights. A low south to southwest horizon is recommended too. As the Milky Way's core doesn't fully rise from the UK, aim for as low a horizon as possible. A simple tripod setup will help with portability to get to those really dark spots.

STEP 4

A wide-angle lens will allow you to take longer exposures without the issue of star trails. The 500 rule states that the longest exposure you can get away with will be 500 divided by the focal length of your lens, so a 28mm lens would give you 500/28 =17.9 seconds. Set the lens to manual focus and a low f-number.

STEP 5

In older cameras with peak ISOs around 3200–6400, use 1600. For modern ones use a setting from 3200 to about one-half peak. Pre-focus on a bright star using Live View if available. Use an exposure several seconds shorter than the value in Step 4 and frame your shot with the horizon parallel to the image frame.



STEP 6

Use a remote shutter release to take your shot. Experiment with settings (increased ISO, longer exposures, etc) for best results. Processing can be used to enhance your photo, such as a boost to brightness and contrast. Adjust red, green and blue channels by dragging their mid-point sliders to help remove light pollution.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

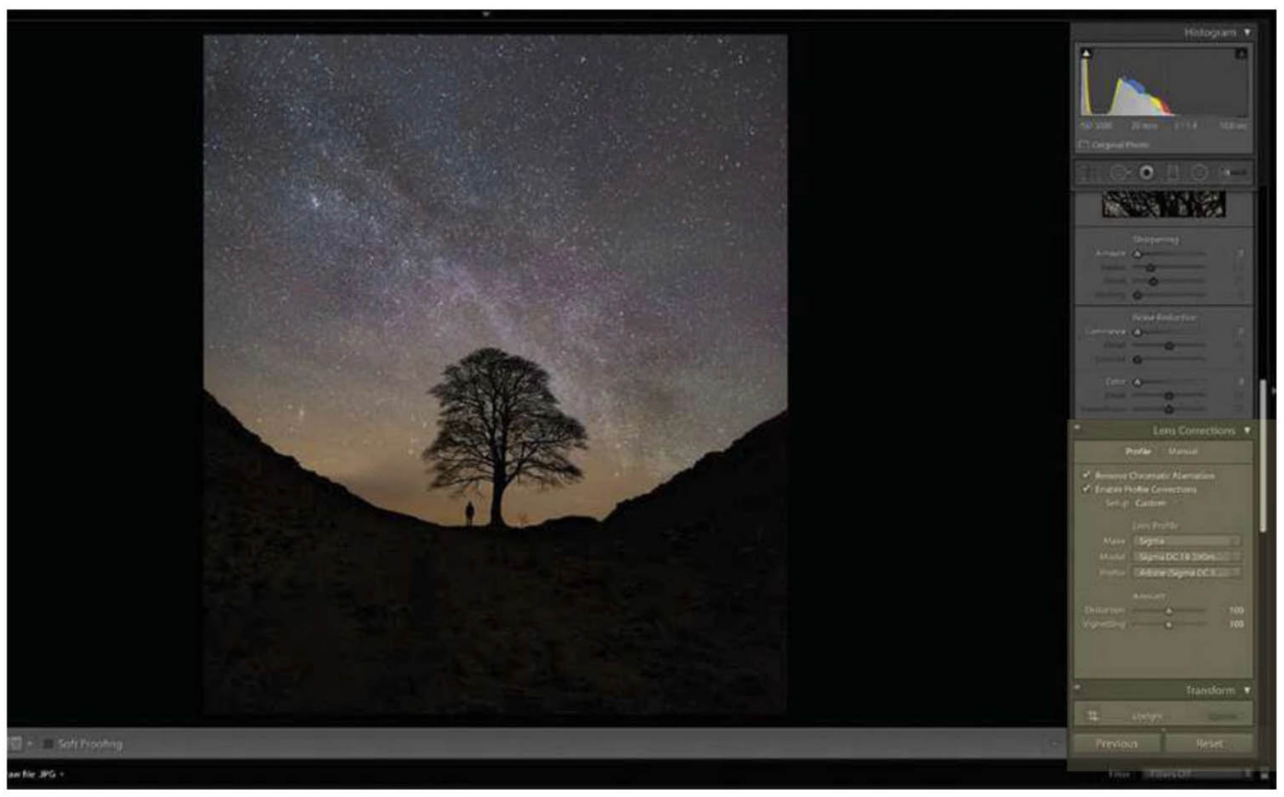
Insight Investment **Astronomy Photographer of the Year**

Advice from a 2018 shortlisted People and Space entrant

IIAPY Masterclass

Landscaping the Milky way

How a landmark can be used to frame a remarkable image of our Galaxy



▲ **The Lens Corrections tool is used to help flatten the image**

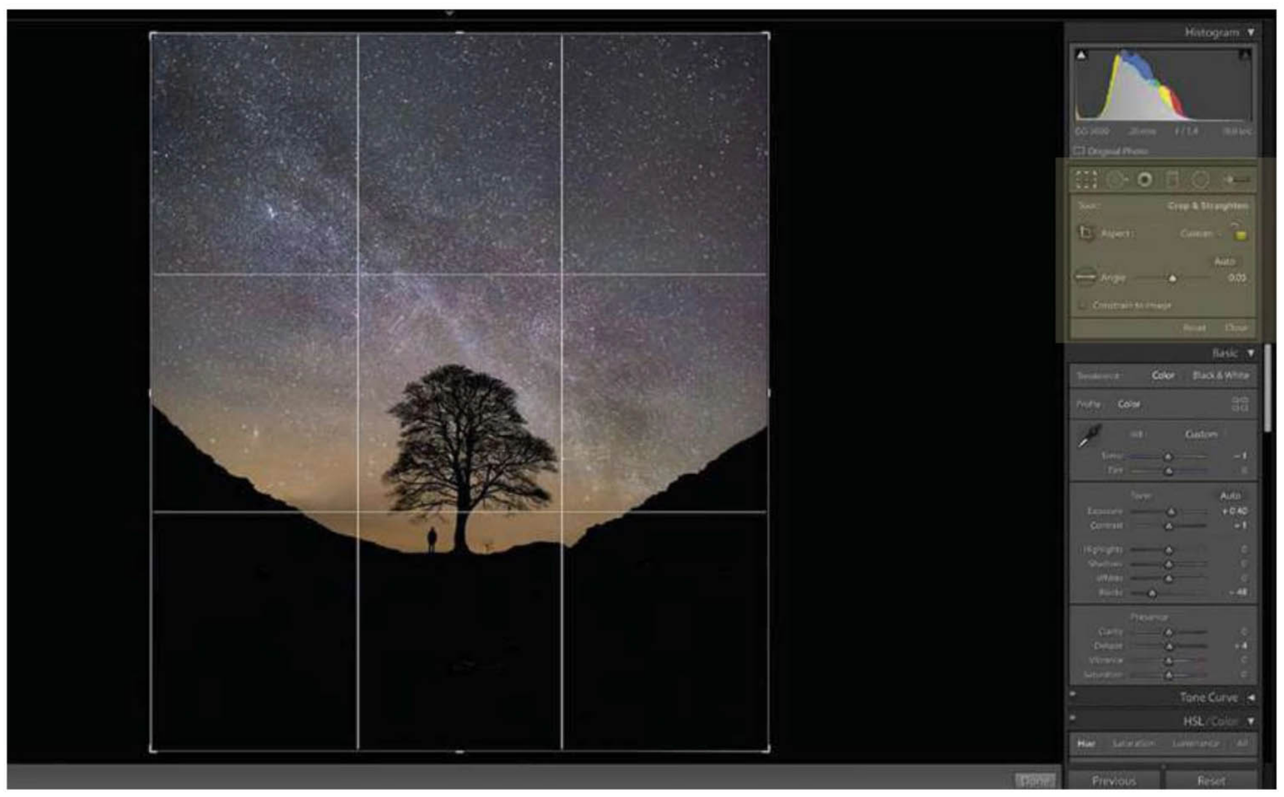
Capturing the majesty of the Milky Way, but with a twist, is a challenge and that's why adding an interesting landscape can make a difference. To add that inspiration to the image which I submitted to the IIAPY, I chose an iconic tree for the foreground and placed myself in the view, and the image was highly commended.

Sycamore Gap at Hadrian's Wall is a great location for any budding astrophotographer or seasoned pro, with simple access – it's just a 25-minute walk from the car park. when I took my image it was cold and snowy, just after Christmas, in the early hours of the morning, so it was quite a challenge – but worth it in the end. The basic colour image was taken with a Nikon D810 DSLR using a 20mm Sigma 1.4 art lens focused to infinity, with a focal length of f/1.4 and ISO setting of 5000. To capture myself in the view I used the camera's inbuilt intervalometer set for intervals of one second and exposures of 10 seconds and up to 999 frames. I then set it running and got into position and chose the frames with me in it.

Getting ready

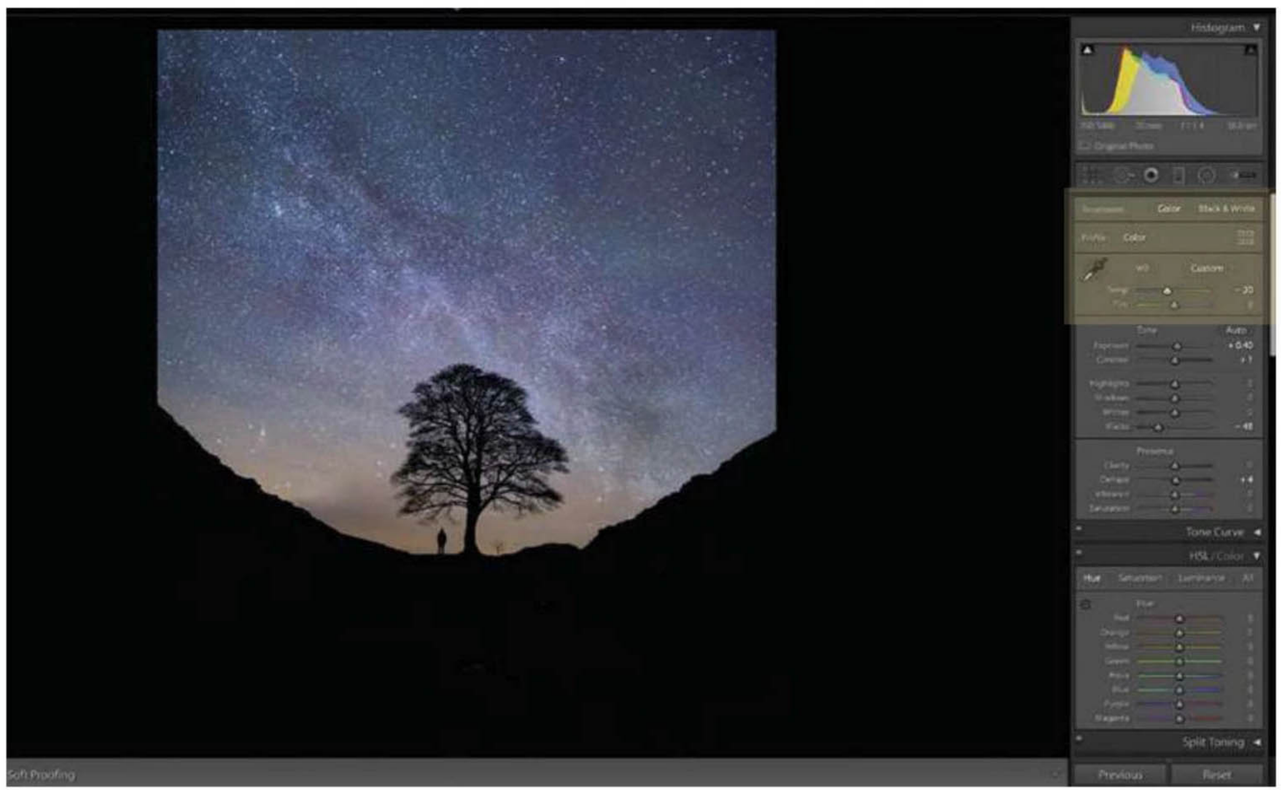
Using Adobe Photoshop Lightroom, I opened the image to be processed. It's difficult to capture a wide-angle image without some distortion, so my first task was to use the Lens Corrections tool and I used the Sigma settings to help flatten the image and remove the vignette (loss of clarity at the edges). This was achieved by adjusting the sliders on the bottom right side to achieve the look I wanted.

I used the Crop tool to crop the image so that the person in the image (me) was about a third of the way up. This is known as the rule of thirds and gives a better balance to the composition, especially when there is a horizon in the view. The Crop tool can also be used to straighten the image, both vertically and horizontally, if for some reason the setup is not quite level. Astrophotographers often set up in the dark and it's easy to be out very slightly, especially when your horizon is as strongly curved as it is at Sycamore Gap.

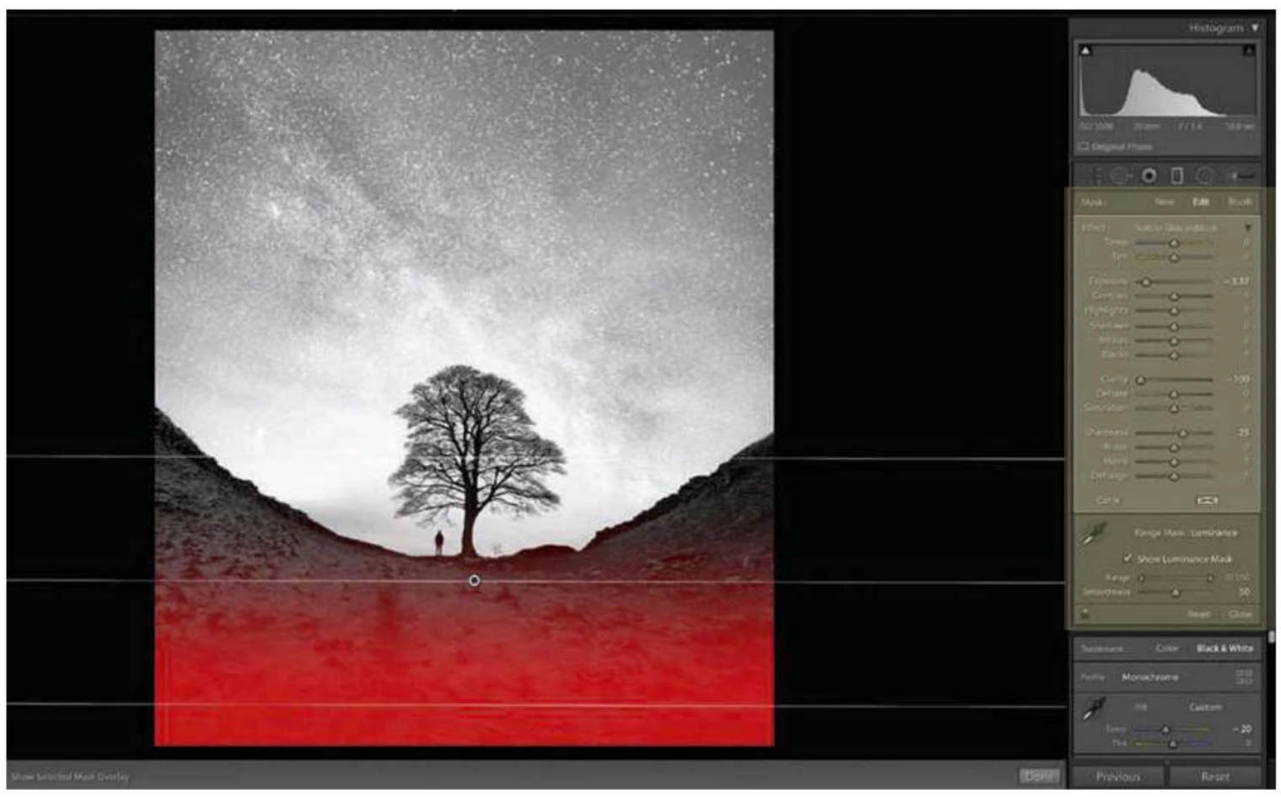


▼ **Using the Crop tool the image is framed so the tree and person are a third of the way up**

ALL PICTURES: MARK MCNEILL



▲ White balance adjustment helps to reduce the light-pollution under the tree



A wide-angle lens can still produce distorted stars in the upper areas of the image, so cropping out the upper part of the picture helped improve the star field while placing the tree and myself in a better position.

Next, I adjusted the white balance of the image, which was still a colour version. My intention was to create a stronger looking image so, using the slider, I changed the white balance to –20. In the colour image this has the effect of making the sky look bluer or 'cooler'. It also helped to reduce the glow of light pollution from Carlisle, which was appearing underneath and to the left of the tree.

▲ The gradient tool is used to make the foreground as dark as possible

▲ Final touches with exposure, Black highlight and Dehaze settings

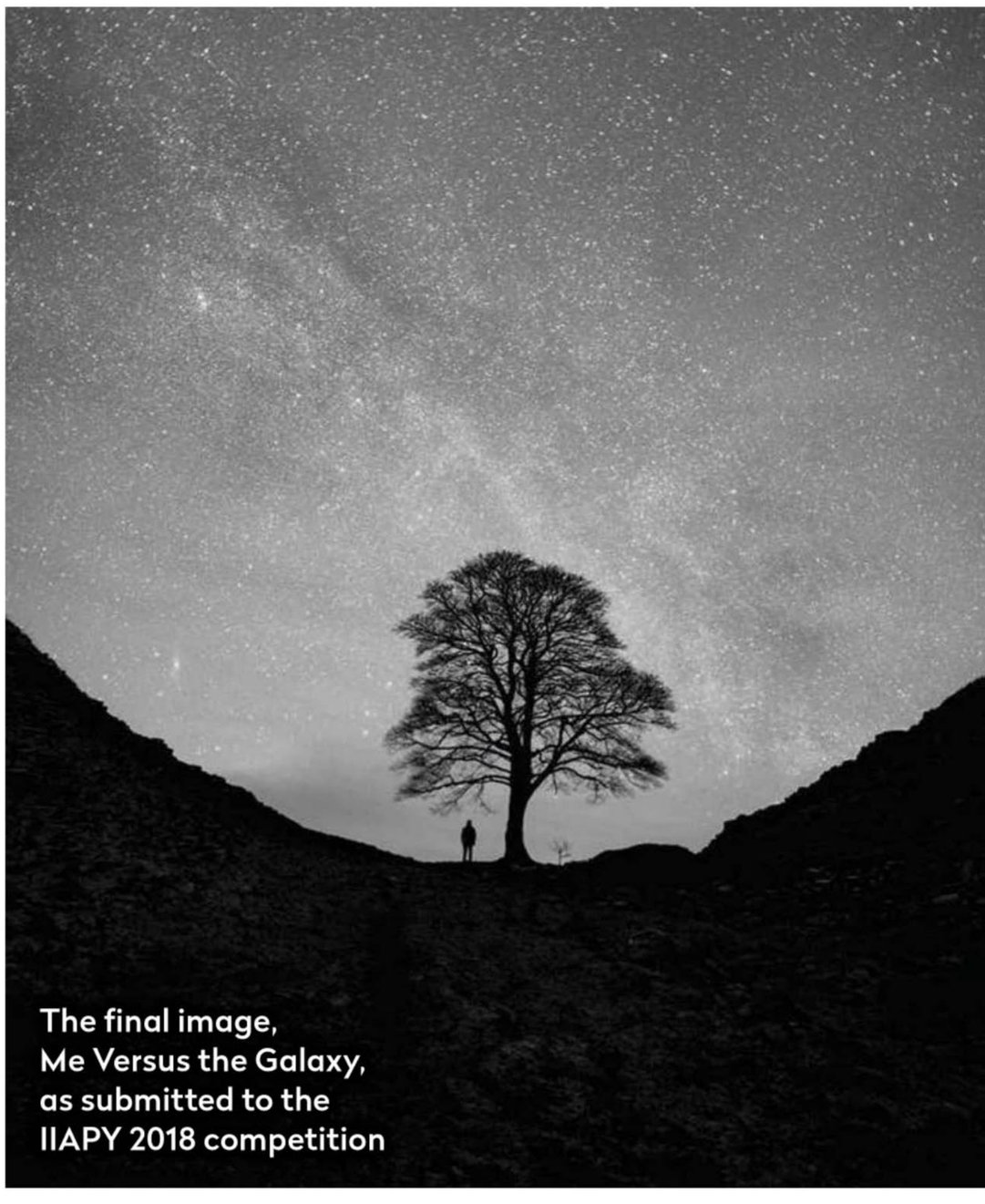
I experimented with different versions, by adjusting brightness and clarity to get an image I was happy with, but I did notice that the foreground could just be seen with snow covered rocks in abundance. Noting how the tree stood out in silhouette gave me the idea of converting the image to black and white for a more dramatic effect.

To reduce the view of the foreground rocks, I copied the image and pasted it as a layer to use as a mask. I then used the Reverse gradient tool on the lower third of the mask to make the foreground as dark as possible, which helped hide the rocks. Next, on the background layer I lifted the exposure in the sky and added a little contrast to make the tree stand out. I was careful not to make the night sky too bright, as that would lose the details of the Milky Way.

To make final tweaks, I increased the exposure setting, adjusting the highlights by moving the 'black' slider down so the foreground was jet black. The Dehaze setting worked better than the Clarity slider and it gave the black and white image a 'harder' look.

Finally, the image was flattened and saved as a finished version. Many images are submitted to the IIAPY in colour, but I felt a black and white image brought out the scene's starkness, with a lone figure beside the tree and the vastness of our Milky Way as a backdrop.

Mark McNeill is a landscape and astrophotographer from the northwest of England. He was shortlisted at the IIAPY in 2018 for his image entitled 'Me versus the Galaxy'

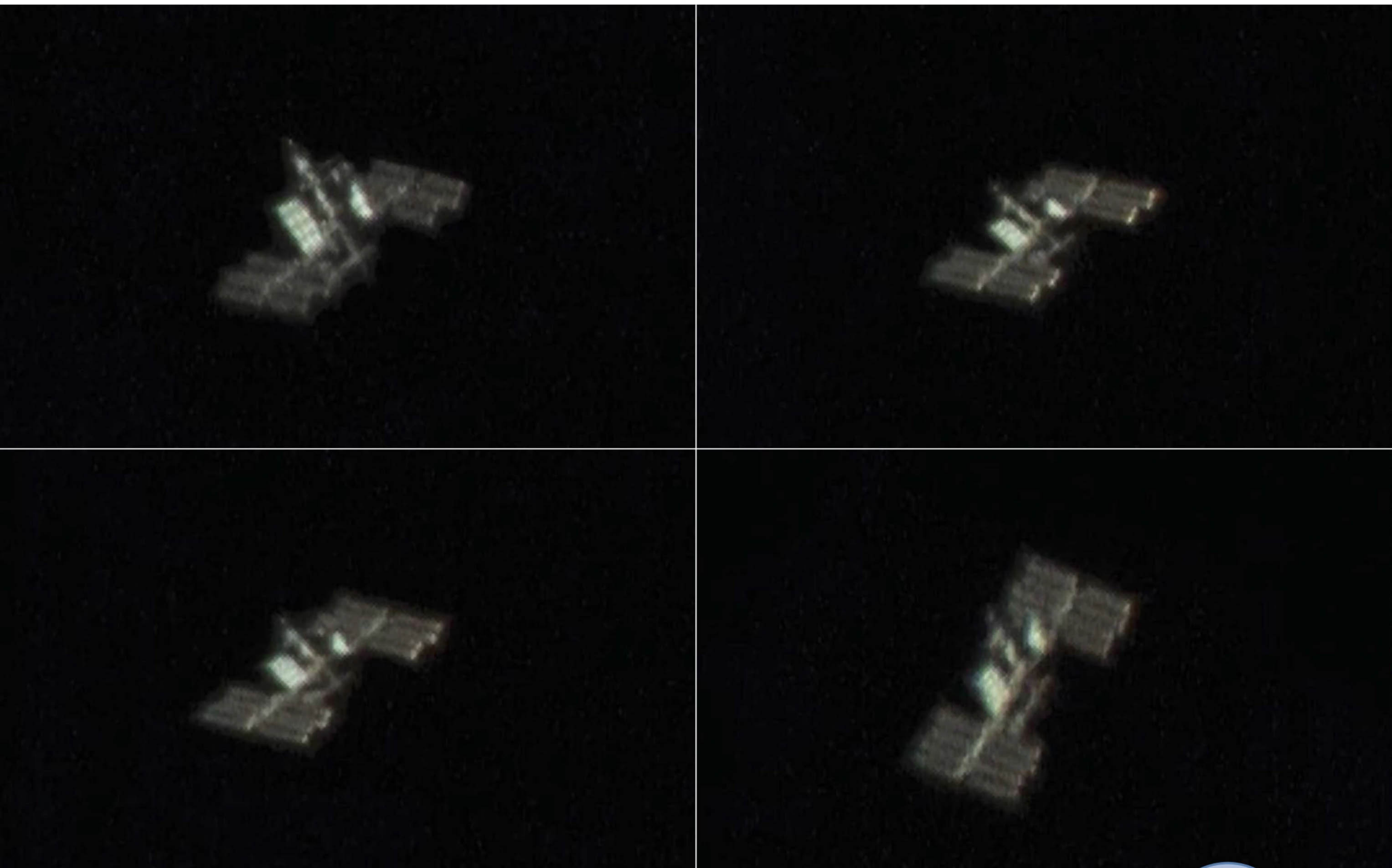


The final image, Me Versus the Galaxy, as submitted to the IIAPY 2018 competition

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

More ONLINE
A gallery containing these and more of your images



△ International Space Station

PHOTO OF THE MONTH

Rich Addis, Wallasey, 28 March 2019

Rich says: "I prepared by getting my scope out two hours early to let it cool down. I then focused on Capella to a pinpoint. I waited until the ISS came by and began filming while manually tracking it across the sky, moving the scope by hand and following it in the red dot finder."

Equipment: ZWO ASI120MC CMOS camera, Celestron NexStar 6SE Schmidt-Cassegrain.

Exposure: best of 100 frames
Software: Firecapture, Photoshop

Rich's top tips: "Use an app like ISS Finder to predict when the ISS will pass your location. Consider the duration of the pass, the start and end points and the altitude. The higher the better. Practise with exposure times for different magnitudes. If it's too bright, detail will be blown out, but too low and you will get the ISS body and not the sails. I used 0.55 milliseconds. Use a red dot finder and keep the dot over the ISS to ensure it's in frame. As accurate as you are, the Space Station will only be present in a fraction of your frames. Be prepared to move about when manually tracking. The best spot is when it's overhead but it can be tricky to manoeuvre your scope. I find setting the tripod legs to full extension helps for when I need to get underneath."

▶ Turn to page 66 for more insight about imaging a lost Venus probe and the ISS

◁ The Moon

Neil Macleod, Alberta, Canada, 20 March 2019

Neil says: "The Moon has so many interesting details, you never run out of areas to observe. The structures of the surface, the lava lakes and sunken craters make great geological observations."

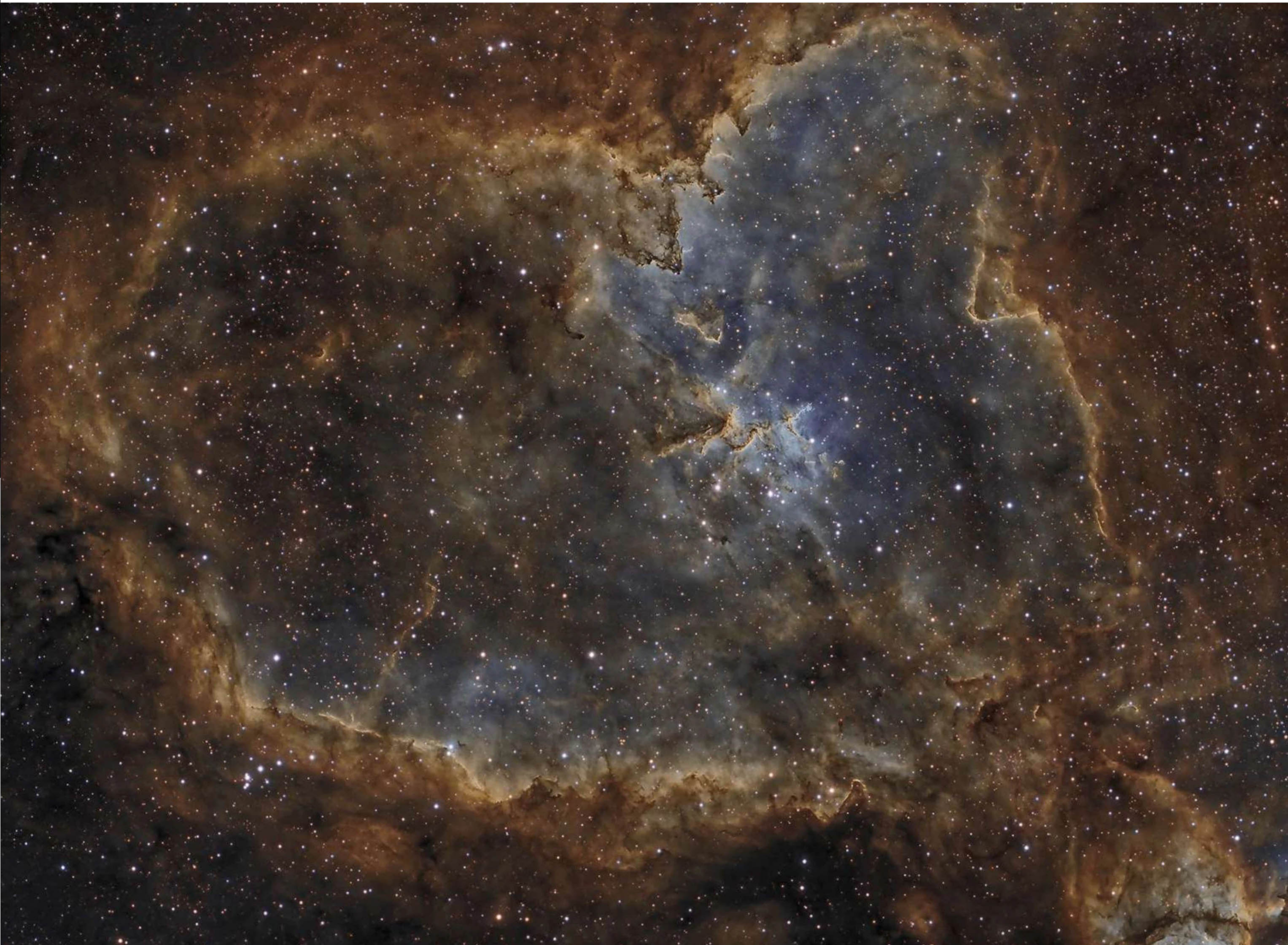
Equipment: ZWO ASI 120MC CMOS camera, Orion SkyQyest XT8i IntelliScope Dobsonian. **Exposure:** 16 tiles; approx. 170 stacked frames per tile. **Software:** Photoshop, RegiStax

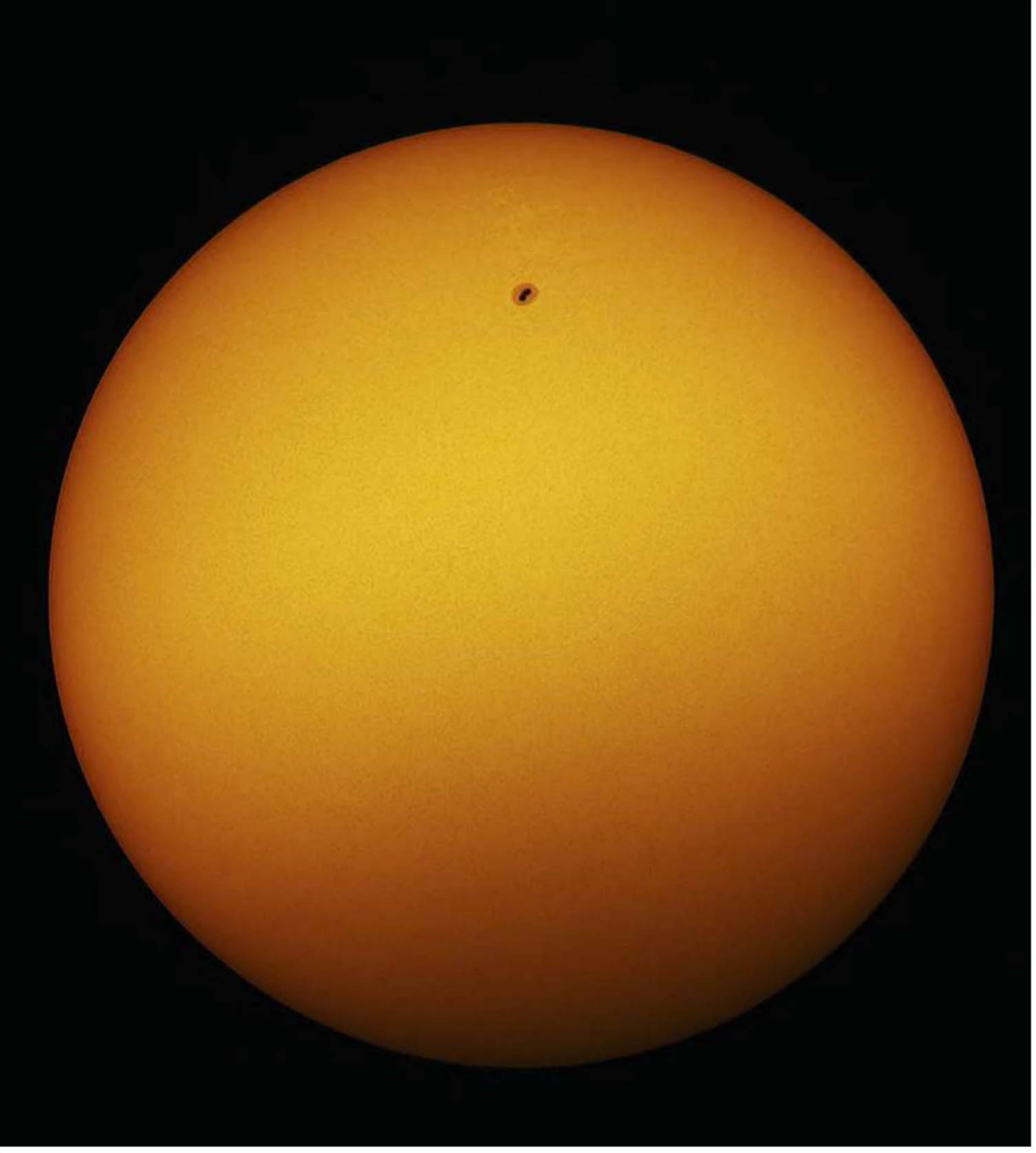
▽ The Heart Nebula

César Blanco González, León, Spain, September 2018

César says: "I have always loved photographing this nebula because of interesting areas like the Melotte 15 cluster at its centre. The biggest challenge was to centre the object to get the most of the heart and a part of NGC 896."

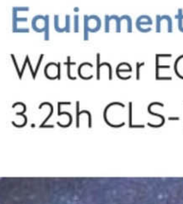
Equipment: QSI 583WSG mono CCD camera, Takahashi FSQ-106ED refractor. **Exposure:** 24x15', 40x10' Ha; 8x15', 32x10' OIII; 8x15', 32x10' SII. **Software:** Maxim DL, Photoshop, PixInsight





◁ AR12738

Graham Algeo, Northamptonshire, 10 April 2019



Graham says: "After trying some re-learned processing and capture techniques on old solar data, I wanted an opportunity to bring it all together. I had to hurry before the Sun went down, but otherwise all went well."

Equipment: Canon EOS 700D DSLR camera, Sky-Watcher Explorer 200P Dobsonian, Sky-Watcher EQ5 Pro mount. **Exposure:** ISO 100, 14x1/2000" **Software:** AutoStakkert!, RegiStax6, Photoshop

▽ The Andromeda Galaxy

Peter Kurucz, Wurmberg, Germany, 9 September 2018

Peter says: "I was inspired to image Andromeda thanks to a new CMOS camera, a new observing site and a newly optimised Newtonian. Processing data that was acquired using six different filters was a real challenge."

Equipment: ZWO ASI1600 mono camera, 8-inch Newtonian, Sky-Watcher EQ-6 Pro SynScan mount, Astronomik filter set. **Exposure:** 3.25h CLS-L-RGB; 2h Ha. **Software:** PixInsight, Photoshop, Lightroom

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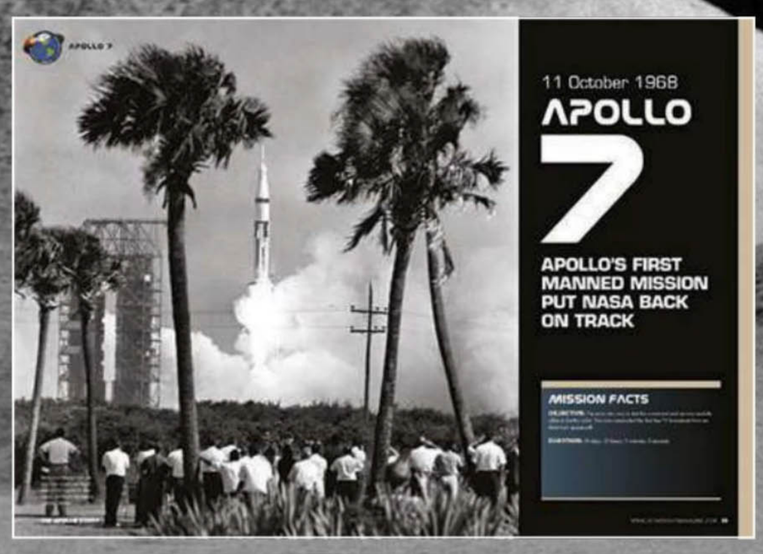

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★★★★★ Outstanding ★★★★½ Very good
★★★½★ Good ★★½★★ Average ★½★★★ Poor/avoid

Our experts review the latest kit

FIRST LIGHT

Celestron RASA-8 telescope

A grab-and-go deep sky instrument tailored for wide-field imaging

WORDS: PETE LAWRENCE

VITAL STATS

- **Price** £1,849
- **Optics** Rowe Ackermann Schmidt
- **Aperture** 8-inch (203mm)
- **Focal length** 400mm (f/2)
- **Focuser** Ultra stable focusing system
- **Extras** M42 camera adaptor, C-thread camera adaptor, fan battery pack
- **Weight** 7.7kg (17lbs)
- **Dimensions** 628x235mm
- **Supplier** Celestron UK (David Hinds Ltd)
- **Tel** 01525 852696
- **www.**celestron.uk.com

The Celestron RASA-8 is a telescope designed solely for astrophotography. RASA stands for Rowe-Ackermann Schmidt Astrograph. The Schmidt part is commonly heard in connection with Schmidt-Cassegrain telescopes (SCTs) and refers to a design introduced by Bernhard Schmidt in 1930, which uses a fast primary mirror and a front corrector plate. The corrector plate (aspheric lens) adjusts incoming light so that spherical aberrations in the primary mirror are compensated for. Celestron produce several RASA instruments, including the RASA-8 (203mm aperture), RASA-11 (279mm aperture) and RASA-14 (356mm aperture).

The RASA design represents a further refinement introduced by astronomers and optical experts David Rowe and Mark Ackermann. Here the converging light cone additionally passes through a 4-element rare-earth lens group mounted where you would expect to find the secondary mirror in a conventional SCT. Rare earth elements are used in lens manufacture because of their low dispersion properties, which helps minimise colour fringing. The RASA's flat focal plane sits in front of the corrector. The result is an aberration free, colour-corrected image, which delivers full illumination and pin-sharp stars over a 22mm image circle with only minimal performance loss over a 32mm-image circle.

Need for speed

The RASA also has an impressive optical speed. This is a comparative value used to indicate how quickly an exposure of certain depth can be achieved. In astronomy, the speed of a telescope is also known as its focal ratio. It can be determined by dividing the scope's effective focal length by its aperture using the same units. The RASA-8 has an effective focal length of 400mm and an aperture of 203mm, hence its focal-ratio is f/2.

In the world of astrophotography f/2 is fast, indicating the RASA-8 can deliver seriously deep sky images in a short time. As an example, an f/2 system ►

The F/2 optics advantage

The ultimate question is whether the RASA design works. Does it deliver a flat, well-illuminated field and does it deliver it quickly despite the light blockage from an attached camera? The answer is a resounding yes, it does its job as described and we can say with confidence that this is a serious contender in the field of astrophotography. Stars appeared sharp right to the edge of our test frames and we detected no anomalous issues when bright stars were in the field either. The optics are also optimised to focus across a wavelength range of 390–800 nanometres, which is excellent. The f/2 system is impressive, allowing you to get very deep images quickly. The RASA's wide-field is perfect for large deep-sky objects or clusters of objects such as galaxies. Combined with the fast optics, this is a scope which is very forgiving of tracking issues; a perfect portable scope for deep sky imaging. This is echoed by the RASA's simplicity – once pointed, tracked and focused, all you need do is sit back, relax and watch your masterpiece unfold.

Fan cooling

Like any enclosed telescope tube, the RASA-8 needs to be left to cool so its temperature matches its surroundings. A dry-cell battery pack can be plugged into the rear of the mirror cell, which powers fan cooling for faster thermal equalisation.

SCALE

Ultra-Stable Focus System (USFS)

SCTs are focused by turning a focus knob that moves the primary mirror back and forth. However, early focus designs suffered from mirror shift, which caused the image to move depending on which way the focus knob was being rotated. The RASA design eliminates this issue with a new 'ultra-stable focus system'.

Optical tube

The optical tube assembly is robust and well made. The main tube is constructed from aluminium, which – combined with the relatively small size of the RASA-8 – makes the scope very manageable. The carry handle at the rear of the instrument made handling the RASA-8 very easy.

KIT TO ADD

1. Celestron Canon Mirrorless Camera Adaptor for RASA-8 telescope

2. Celestron RASA-8 light pollution imaging filter

3. Celestron focuser motor for SCT, Edge HD and RASA telescopes

▸ delivers images of the same exposure depth as an f/10 system in just a twenty-fifth of the time.

Focus issues

There are negatives that need mentioning. No finder is included which, considering the price of the instrument, seems mean. Also, DSLRs aren't compatible because focus cannot be achieved. However, Canon and Sony mirrorless models (APS-C or full-fame) should be fine. Various adaptors are available for different camera threads, but some cameras require spacers to get them into the correct focus position. The RASA-8 has 25mm back focus from the camera adaptor ring, so if the distance from the camera's front aperture to the sensor is greater than this, as is the case with a DSLR, focus isn't possible.

The RASA-8's limited back focus precludes the use of regular filter wheels, which are used in RGB (red, green and blue) or narrowband imaging. A Baader low-profile filter holder is now at the prototype stage, with a release expected later in 2019. Its use will require a camera with a maximum back focus distance of 13mm.

Nevertheless, focusing was precise and the on-axis nature of the front-mounted camera made mount balancing easy too. We were impressed with the depth we could get with short exposures. Using an Atik 314L+ cooled CCD camera (11mm diagonal sensor), we reached mag. +15 in just one second. Under less than perfect skies we were able to record mag. +17.5 galaxies with 30 second exposures. A 30 second image of the Leo Triplet – M65, M66 and NGC 3628 – provided detail in each galaxy. It was good to see the entire triplet fitting in the delivered 60x90 arcminute image frame.

We really enjoyed using this scope as it's light and easy to handle. In addition, its fast optical speed and relatively wide-field capability make it ideal for setups where alignment isn't extremely precise. In this respect it's an amazing grab-and-go deep sky instrument.

VERDICT

Build and design	★★★★½
Ease of use	★★★★½
Features	★★★★★
Imaging quality	★★★★½
Optics	★★★★★
OVERALL	★★★★½

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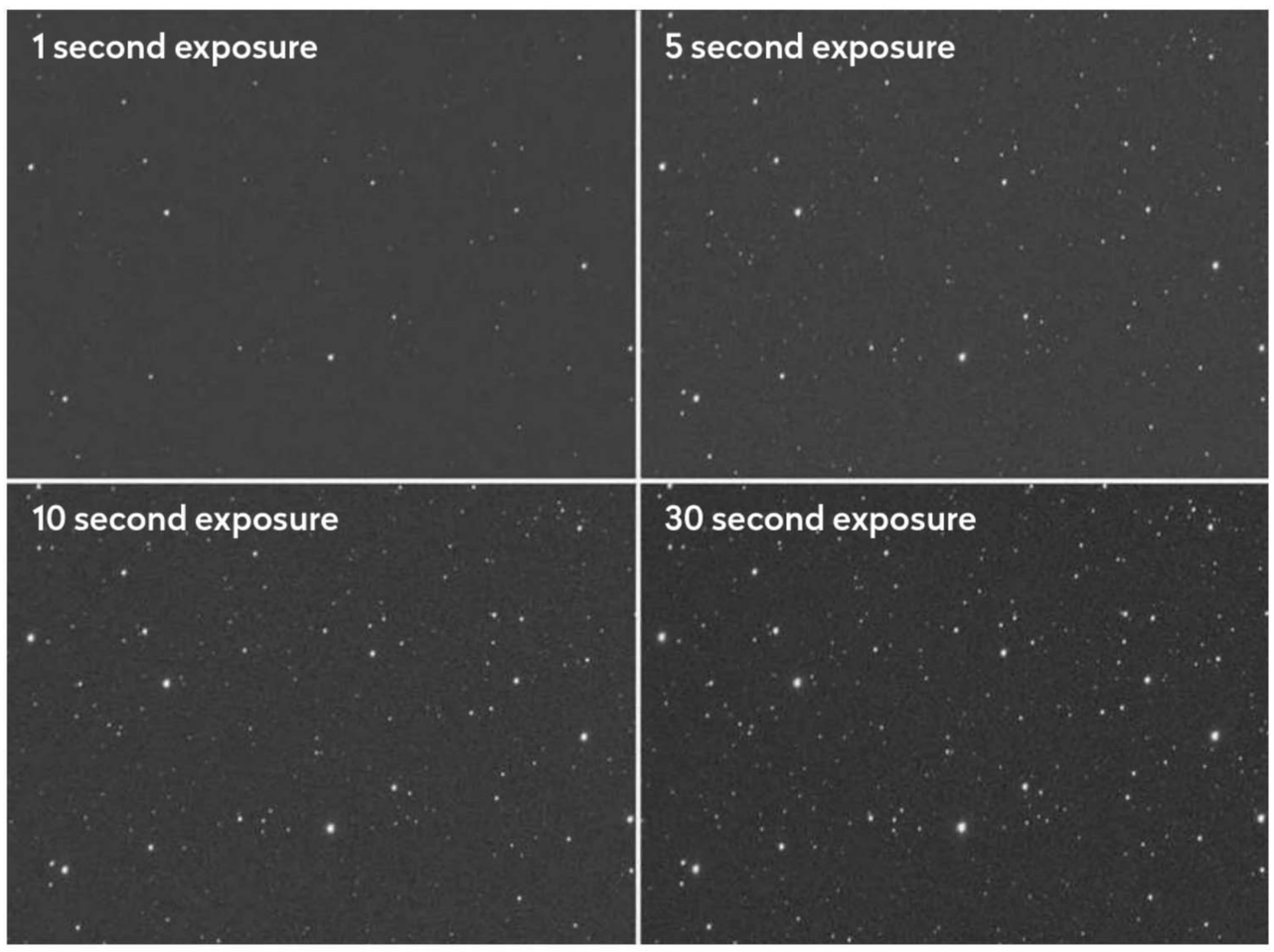
CGE dovetail bar

The RASA tube has a CGE dovetail bar that runs along the full length of the optical tube. This bar is compatible with Celestron CGE mounts as well as the popular Losmandy-style dovetail clamp. A safety knob is provided to prevent the tube from slipping down and out of the clamp.

Camera adaptors

Cameras fit to the telescope via adaptor rings. Two are supplied as standard – M42 and C-type. The adaptor ring fits inside a threaded collar which can be screwed onto a projecting thread on the front-centre of the corrector plate. In terms of photographic cameras, it's worth noting that regular DSLRs are not supported but some mirrorless-models are.



▲ A comparison of 1, 5 and 10 and 30 second exposures on a random star field in Gemini reveals how quickly the RASA-8 digs deep. The 1 second image records stars down to 15th magnitude while the 30 second exposure approaches mag. +18

▲ An uncalibrated integration of 25 images with a 30 second exposure, revealing detail in the Leo Triplet of galaxies, and illustrating the field of view from an 11mm diagonal sensor camera attached to the RASA-8

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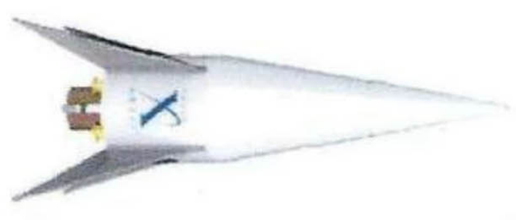


Our experts tell you what they think of the latest kit

FIRST LIGHT

Knightware Deep-Sky Planner Mobile Edition

Easy to use software that helps you construct a personalised observing plan

WORDS: STEVE RICHARDS

VITAL STATS

- **Price** £10.99
- **Delivery method** Download
- **Manual software** Manual
- **Updates** Available online
- **System requirements** Android 4.4 and later, iOS 8 and later
- **Developer** Phyllis K Lang, Knightware LLC
- **Email** Via website link
- **www.** knightware.biz

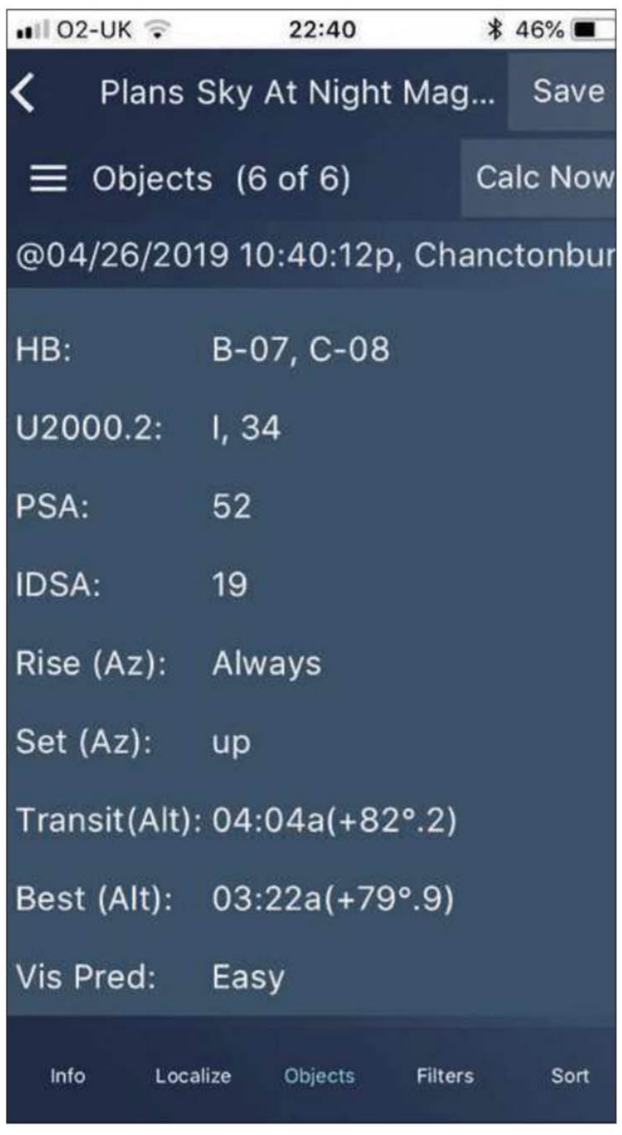
With so many potential objects to observe or image, it makes sense to plan your observing sessions in advance to take full advantage of clear sky opportunities. Knowing which celestial objects are suitably placed in the night sky at any one time is key to a fruitful observing session. Knightware's Deep-Sky Planner Mobile Edition (DSPME) is designed to help such planning. It's a portable solution that is simple and fast to use and which gives you mobile access to existing observing plans.

Whereas the desktop version of the software, Deep-Sky Planner 7, has access to numerous catalogues, DSPME doesn't have any databases. Instead it relies on existing observing plans that can be downloaded from the Deep-Sky Planner (DSP) community website or generated on your own desktop version of the software.

As existing users of the desktop version, we were keen to discover how useful this mobile version would be in the field. The software is available for download from the App Store for iOS users (v8 and later), or from Google Play for Android users (v4.4 and later) and is designed primarily for iPads and Android tablets, but it can also be used with smartphones. We carried out this review using our own iPhone SE, but the small screen area meant that some of the displays were overly cramped and required a fair amount of scrolling.

First steps

The download and install worked flawlessly after connecting to the App Store and paying for the app via our iPhone. With the software installed, the next task is to set up your site location and time zone, so that the software can calculate the position of celestial objects from your specific observing site. ▸



SCREENSHOTS BY STEVE RICHARDS X 5, KNIGHTWARE

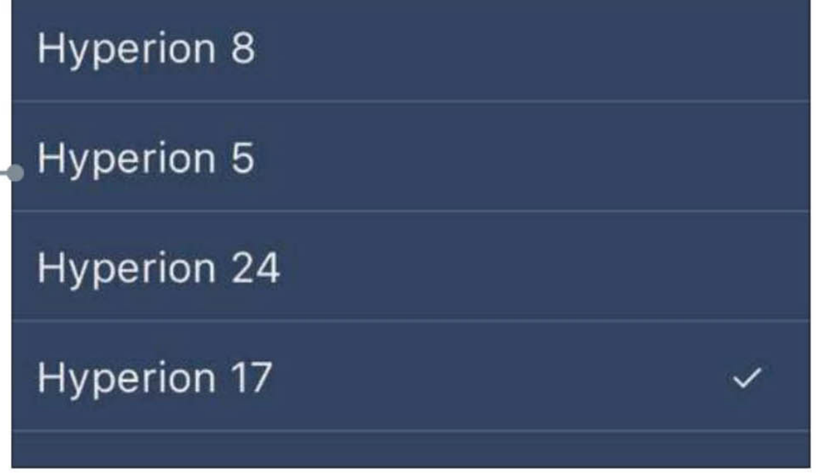
Planning ahead

Using observing plans is a great way of getting the most out of your stargazing session, as they focus on a selected subset of the celestial objects that are available to you. The observing plans used by this app hold a wealth of information, including everything from object type, constellation, RA (Right ascension), dec. (declination), azimuth and altitude at your chosen observing time, local hour angle, air mass, magnitude, B-V colour index, size, position angle, rise and set times, transit time and a visibility prediction.

Just because an object is above your local horizon doesn't mean that you will necessarily be able to successfully observe it. This is where the visibility prediction modelling steps in to offer some guidance based on the equipment you are using, the local conditions and even the personal, fully dark-adapted pupil size of your eyes.

Typical predictions include: easy, moderate, difficult, improbable, too dim, too low, down (below horizon) or in the case of double stars – no split, sec.dim (meaning the primary is visible but the secondary is too dim). You can use these predictions to make observing easy or to deliberately challenge yourself – the choice is yours.

◄ The Deep-Sky Planner Mobile Edition is available for Apple iPhones (left) and tablets with iOS 8 and higher; and Android phones and tablets (right) running version 4.4 and above



Equipment browser

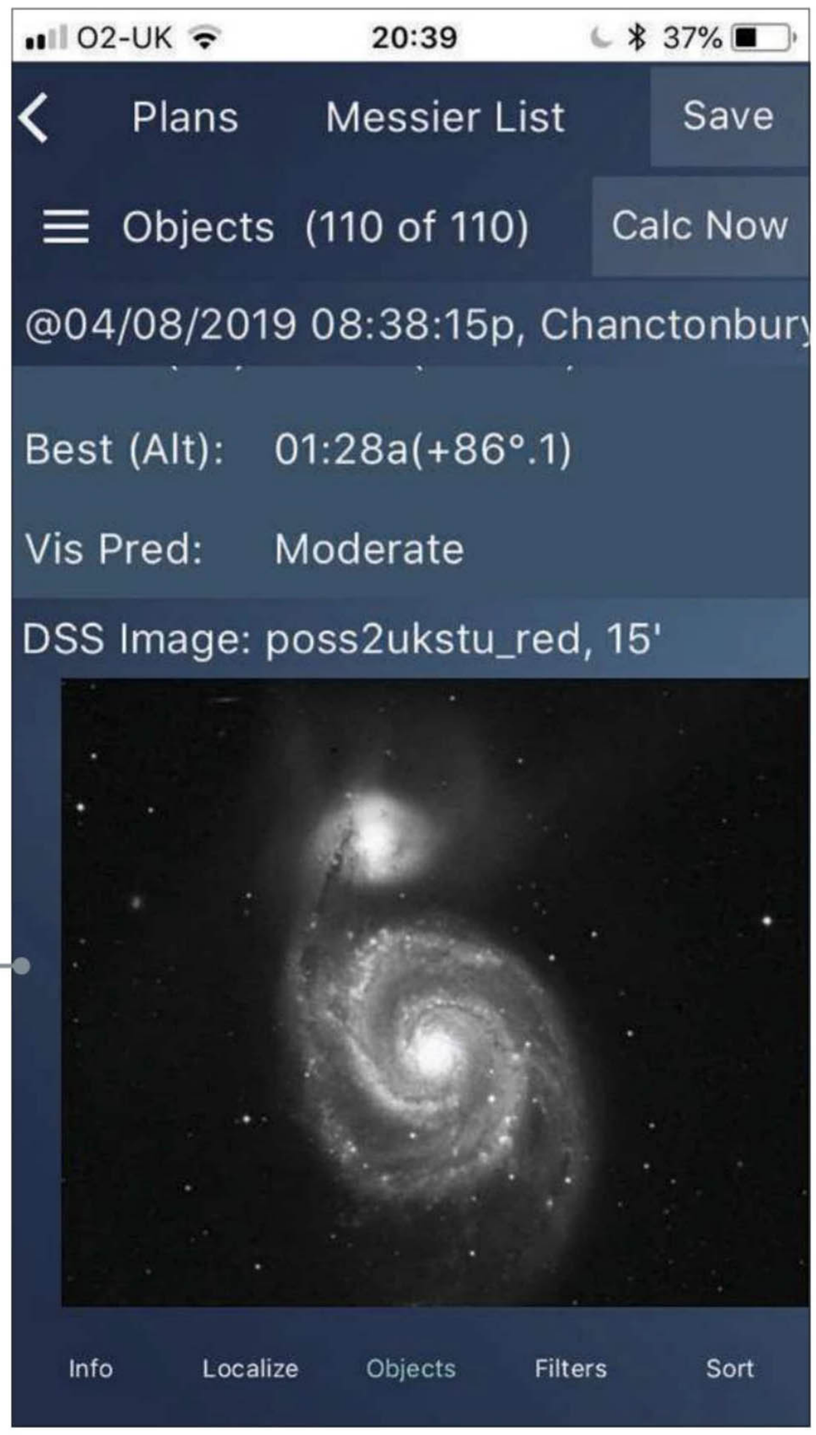
Deep-Sky Planner Mobile Edition references the equipment in use to generate its visibility modelling features and other important attributes. A database of your equipment can be built up from lists on the community website or from an equipment list produced on the desktop version and downloaded via Cloud storage.

Application styles

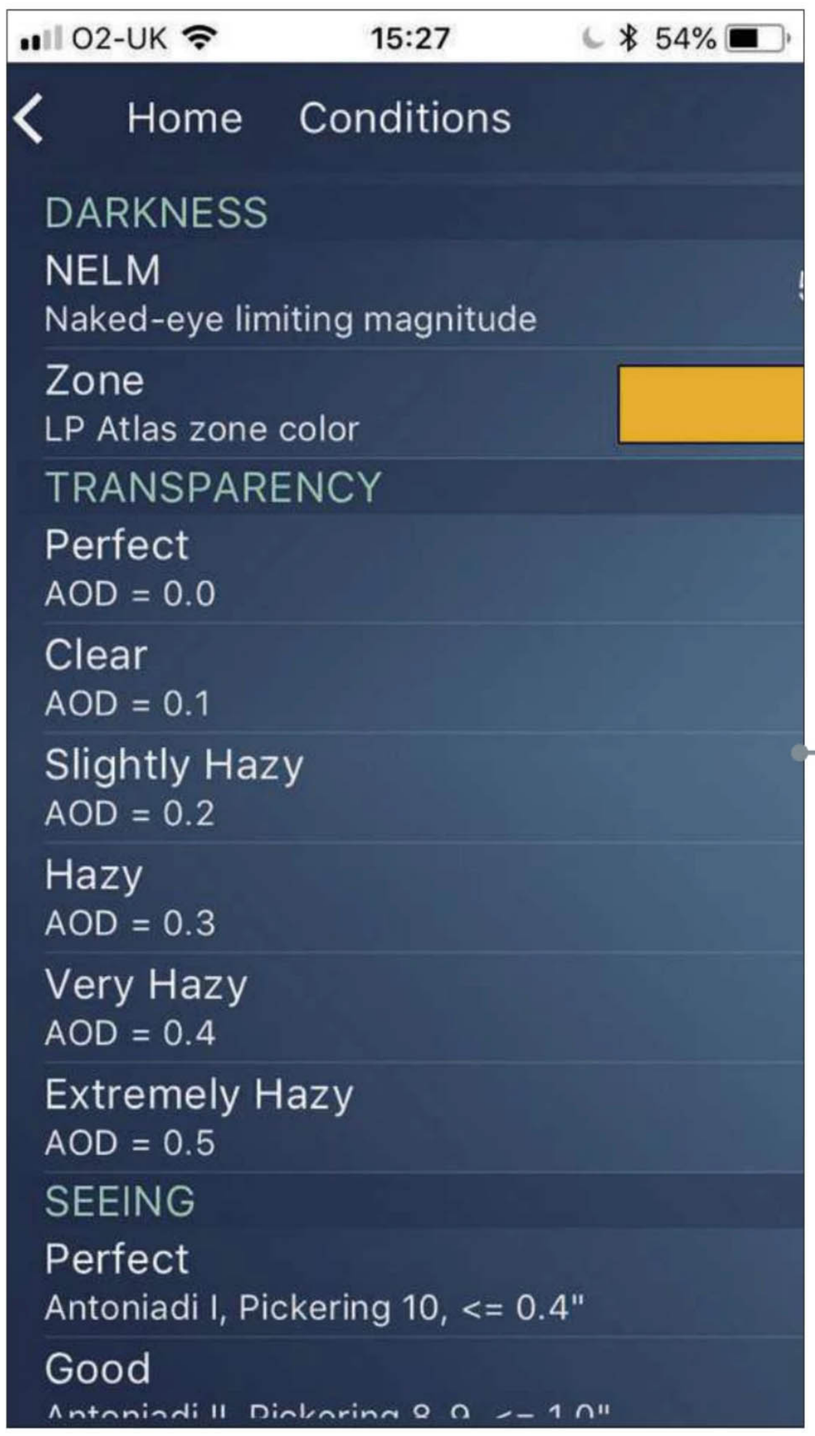
Maintaining your dark-adapted vision is so important for observing dimmer deep sky objects, so we were pleased to note that various application styles were available, all of which were very attractive. Usefully, a red and black style was included. We used this style most of the time when observing.

Digitised sky survey images

It is useful to have a reference image confirming that you have correctly located an object for observing or imaging and the app allows you to download a Digitized Sky Survey (DSS) image of each object in your observing plan. Of course, for this to function, you must have internet access.



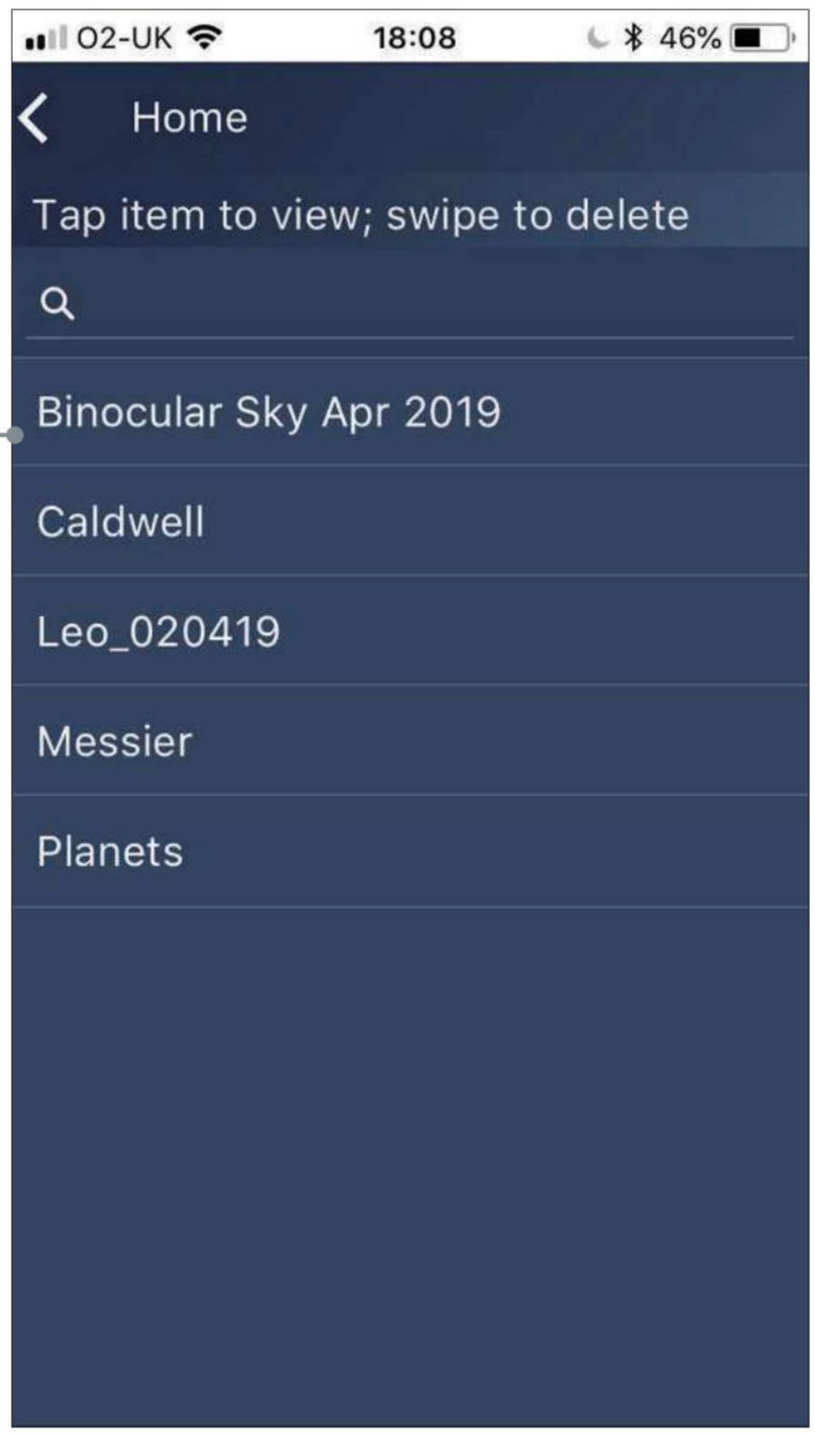
FIRST LIGHT



SCREENSHOTS BY STEVE RICHARDS

Observing plans

Although you can edit and save observing plans, you can't generate them using DSPME, however, there are plenty of plans available on the DSP community website. Alternatively, you can produce your own plans using the desktop version of the software and import them.



Observing conditions

Since observing conditions will vary, it is important to include data relating to the sky conditions at your site so that the visibility modelling features can make the most accurate predictions. The app has very comprehensive settings for darkness, transparency and seeing.

KIT TO ADD

1. A printed sky atlas

2. SkySafari app

3. Deep-Sky Planner for Windows for desktop

▸ Entering the current location is made very simple with a 'Get Position' button, which collects the necessary information from the GPS system on your device. If your tablet or iPad doesn't have GPS, you can use the Geolocation services through the internet to get a reasonable fix on your position. Alternatively, you can get hold of your latitude and longitude from another source and enter the data manually.

We imported eyepiece, telescope and camera data sets as well as test observing plans that had previously been generated from our desktop version, using OneDrive as our cloud server, although Dropbox and Google Drive are also supported by the app. We also downloaded some additional equipment lists from the community website but found that a whole set of manufacturer equipment downloaded each time rather than us being able to choose individual items. This meant that we had to edit the downloaded list to remove all the unwanted items, which was a fairly tiresome task as each item had to be deleted individually. However, equipment lists from our desktop version worked much more efficiently. To make use of the visibility modelling features, we imported our observer profile as this contained information regarding the fully dark-adapted pupil size of our eyes, which forms part of the calculations carried out by the app.

Some observing plans have far more objects in them than you could realistically observe during the current session, so a powerful 'filter' feature allows you to choose which objects will be included by setting magnitude, size, azimuth and altitude limits. You can further filter the plan by selecting object type and constellation making it simple to zero in on just the type of objects that you particularly want to observe.

Pressing the 'Calculate' button after entering your observing time will determine a lot of location and observing data, including a useful Visibility Prediction level based on your location, time and date, selected equipment and local conditions. To help with your observations, you can download images of your chosen objects from the Digitized Sky Survey server.

Although Deep-Sky Planner Mobile Edition can be used independently from the desktop version – if you use the plans available on the community website – we found that the app was most useful when used in conjunction with the desktop version. The app is suitable for observers and imagers with any level of experience who don't want to take a PC outside with them, but are happy to take a small tablet, or, with some limitations, a smartphone with them.

VERDICT

Ease of use	★★★½☆
Extras	★★★★☆
Features	★★★½☆
Functionality	★★★★☆
Installation	★★★★★
OVERALL	★★★★☆

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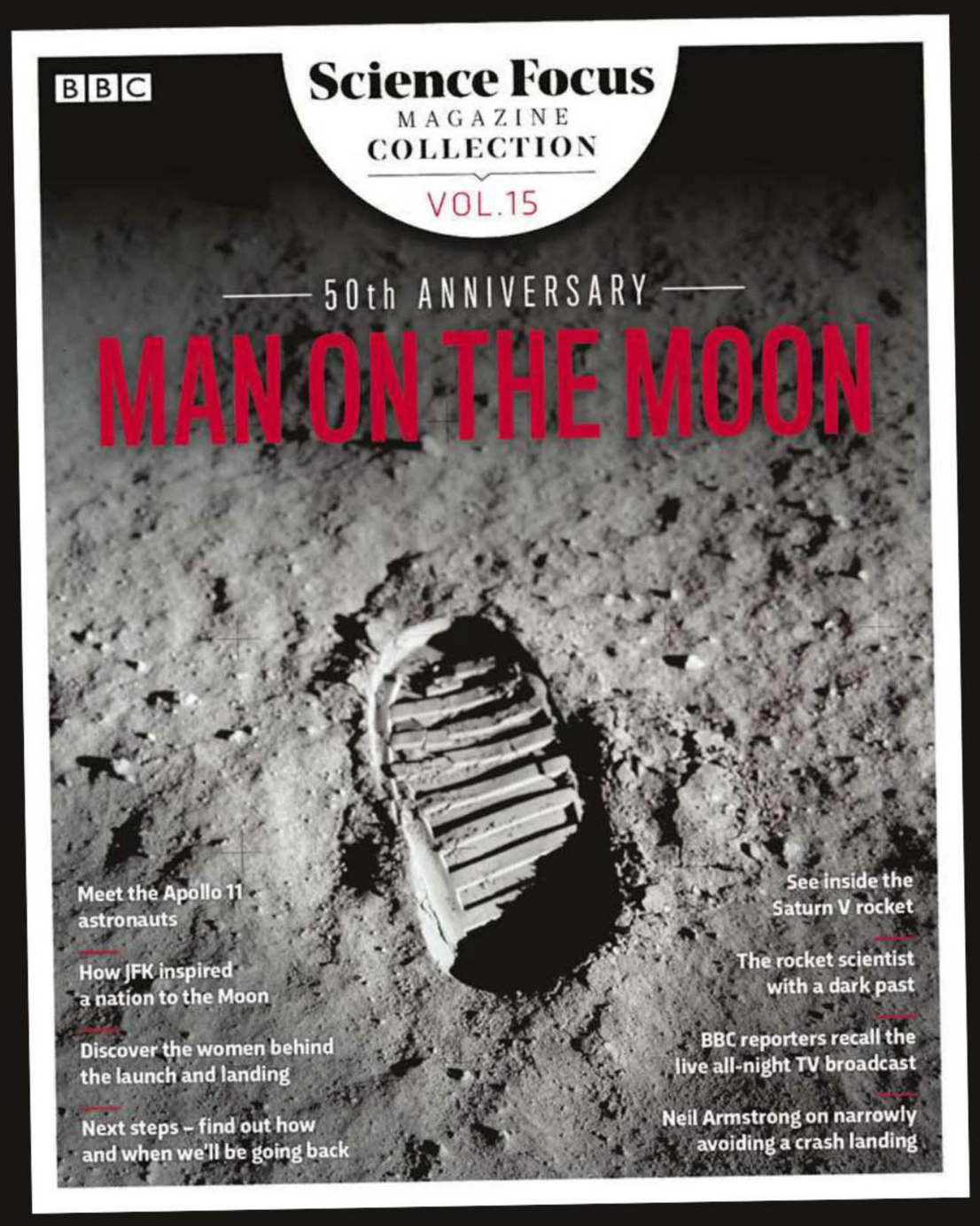
50th ANNIVERSARY

MAN ON THE MOON



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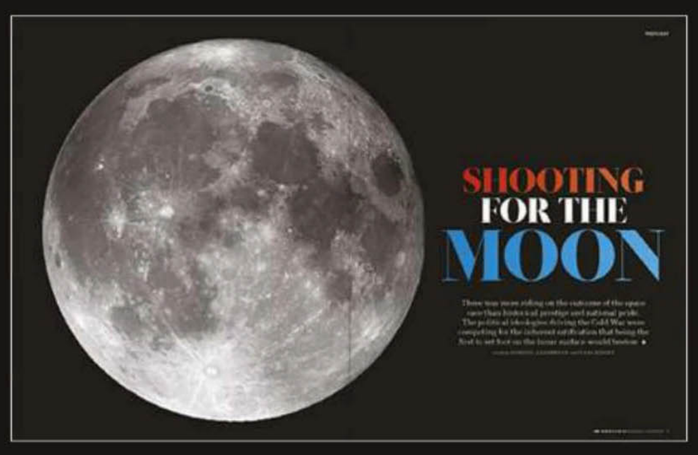

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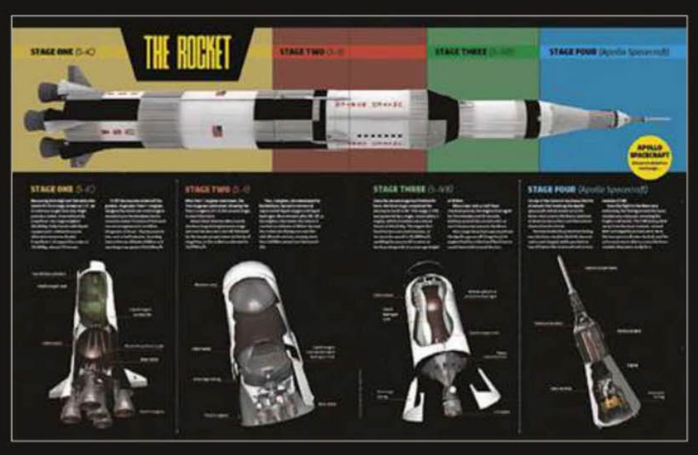

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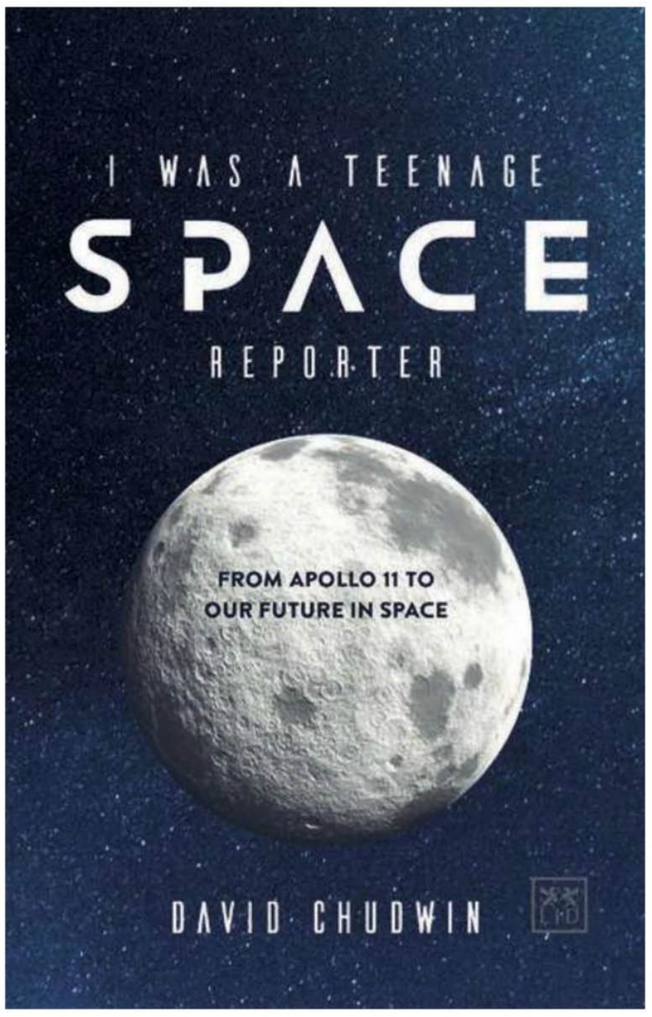


I Was a Teenage Space Reporter

David Chudwin
LID Publishing
£9.99 ● PB

A nicely produced volume with an irresistible title, this is the memoir of a student reporter – in the right place at the right time – who became the youngest of more than 3,500 media representatives covering the launch of Apollo 11 from Florida's Kennedy Space Center in July 1969. David Chudwin starts by recalling life growing up in the early Space Age, shares details – and unique photos – from his behind the scenes access to the launch preparations, then goes on to reflect upon those glory days to help forecast the next half century in space.

Sounds great, right? The snag is that it should be called 'I Was *Only* A Teenage Space Reporter'. While a lifelong space enthusiast, the author chose not to remain in journalism, and unfortunately, it shows in the prose. Much of the book is written autobiographically, but the reader is given too much detail, seemingly transcribed directly from Chudwin's diary of the time. For instance, we not only find out how much his flight cost but also the Sea Missile Hotel's reservation rate and the price of the airport shuttle.

The problem with all this detail is that it displaces potentially more interesting stuff. Chudwin mentions interviewing George Muller, NASA's head of human spaceflight, on the eve of the Apollo 11 launch about his personal view of space exploration post-Apollo – material that would get modern space historians salivating. But not one word of that makes it into this book.

The author then recounts the Apollo 11 crew's post-flight tour of Chicago and his subsequent autograph hunting, including one extraordinary sentence on the 2009 Apollo 11 anniversary dinner, inadvertently revealing how the madness of crowds works in practice: "My hopes for a personal picture one-on-one with Armstrong were dashed because of the mob around him, but I was able to get some close-up shots of him by elbowing into the crowd".

▲ **Teenager David Chudwin gained access to pre-flight press activity for Apollo 11**

NASA

The book's final section applies lessons learned from Apollo and its aftermath to the future of human spaceflight. The result is a volume suffused with nostalgic detail, but one best suited for Apollo completists rather than a general reader.

★★☆☆☆

***Sean Blair** writes for the European Space Agency website*

Interview with the author David Chudwin

How did you come to get such an amazing opportunity at such a young age?

In 1968 I joined *The Michigan Daily* at the university as the only reporter with a deep interest in space. I wanted a press pass to cover the Saturn V launch in 1969 for the paper. NASA normally did not accredit student journalists, but a colleague working for the College Press Service persuaded them to give me press credentials to cover Apollo 11.

What are your favourite memories from that time?

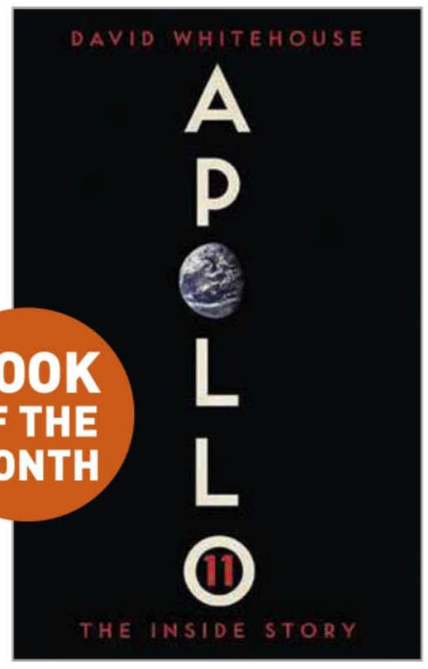
Before the launch we took a NASA press bus at dusk to a vantage point three-quarters of a mile from the rocket. As night fell, high-intensity xenon lights were turned on that bathed the rocket. The second was watching the Apollo 11 crew walking out in their space suits. The launch was an intense physical experience; I felt the deafening sound pounding against my chest, the vibrating ground and heat from the rocket engines.

What do you think are the most important things to take from the Moon landing?

Apollo proved that with strong leadership, sufficient funding and a dedicated workforce almost anything is possible. JFK made the decision in May 1961 to land on the Moon by the end of the decade. US Congress funded NASA with a budget equivalent to twice what the US spends today on space. Then, over 400,000 administrators, engineers, scientists and machinists worked to accomplish that goal: humankind's greatest engineering achievement.

***David Chudwin MD** is a lifelong space enthusiast and public speaker. He was the youngest official reporter to cover the launch of Apollo 11.*

Apollo 11: The Inside Story



David Whitehouse
Icon Books
£12.99 ● PB

When President Kennedy made his famous speech in 1962 committing America 'to go to the Moon' by the end of the decade, the Soviet Union was already well ahead in the Cold War Space Race and had achieved many of the 'firsts'. So how did the Americans manage to get the upper hand? Published in time to mark the 50th anniversary in July of Apollo 11, this is a fast-paced and tremendously readable account of the post-war development of spaceflight, from Nazi Germany's V2 rocket programme to the end of the Apollo programme in 1972.

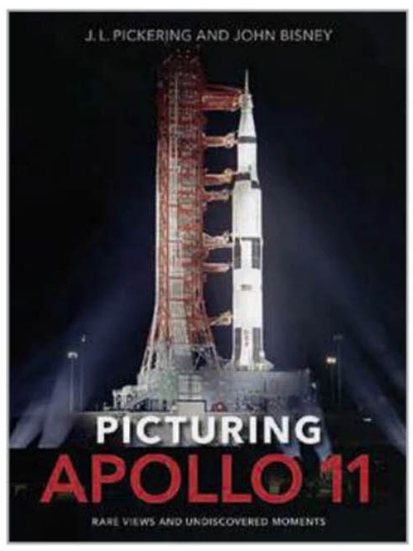
What makes this book really stand out from other Apollo based books is the inclusion of long quotes from interviews with astronauts such as John Glenn (the first American to orbit Earth), Eugene Cernan (the last man to walk on the Moon) and, of course, Neil Armstrong himself. It's these quotes that give an immediacy to the story, illustrating the pressures on the astronauts and NASA to be successful, as well as providing insights into the psychological impacts of space exploration.

Since its demise, people have been arguing about the implications of NASA's Apollo programme. One of its impacts is clear right from the beginning of this book; instead of a picture of the Moon or the Apollo 11 spacecraft itself, the front cover shows the famous 'Earthrise' image, our home planet as seen from deep space. The beauty and fragility of Earth as encapsulated in this photograph may be the single most important legacy of Apollo.

★★★★★

***Pippa Goldschmidt** is an astronomy and science writer*

Picturing Apollo 11



JL Pickering, John Bisney
University Press of Florida
£48.50 ● HB

Whenever we think of Apollo 11, we think of people; not just Armstrong, Collins and Aldrin, but the 400,000 who put the mission together, the million-strong crowd who filled the beaches and roads of Cape Kennedy, and the audience of half a billion who tuned in on radio or TV. Historian JL Pickering and journalist John Bisney's anthology of rare photographs, *Picturing Apollo 11*, honours the people who strove against all odds to land a man on the Moon.

They "make no claim" to reproduce unseen images; all have been available since 1969. Only a handful of their picks are readily recognisable; most have not been seen before.

Picturing Apollo 11 covers January to August 1969, from crew selection until their emergence from quarantine onto the world stage. The authors avoid familiar images in favour of rarer ones, often quirky, including seven-year-old Andy Aldrin trying on his father's helmet.

Pickering and Bisney's book conveys the sense of awe regarding Apollo's monumental scale and the photographic clarity is profound. We see the soon-to-become-iconic lunar module Eagle, festooned with 'Remove Before Flight' streamers, the blue-foil-wrapped command ship Columbia and the mighty Saturn V rocket.

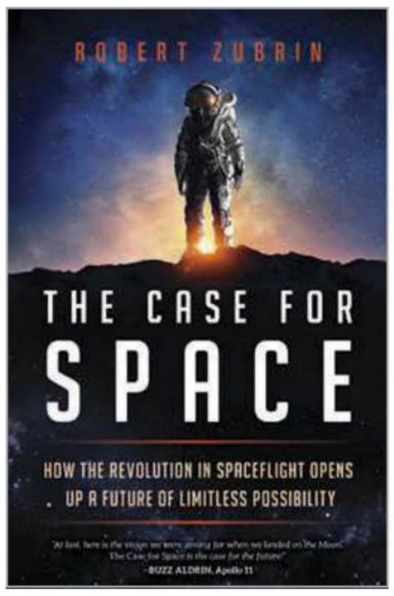
If there is any disappointment (assuredly, no fault of the authors), it's that many images from the Moon are familiar, like Aldrin's boot print in the dust. But there are surprises, too. A close-up of Aldrin at Tranquility Base shows his face, grinning sideways at Armstrong through his gold-tinted visor; an iridescence of life on an otherwise lifeless world.

★★★★★

***Ben Evans** is the author of several books on human spaceflight and is a science and astronomy writer*

The Case for Space

Robert Zubrin
Prometheus Books
£16.95 ● HB



"Multitudes of new worlds yet unknown await, filled with menaces to be faced, challenges to be overcome, wonders to be discovered and history to be made."

In Robert Zubrin's follow-up book to his 1998 *The Case for Mars*, the astronautical engineer, drawing from his extensive and pioneering career in space travel, extends beyond Mars and theorises that space exploration is our only solution for the future survival of our species.

Structured in two parts, the book first explores the 'how' of this thesis, beginning with a comprehensive review of the new generation of explorers such as SpaceX, Bigelow and Blue Origin. He then expands onto bigger and more thought-provoking arguments for lunar, asteroid and planetary colonisation, the availability of rich energy and mineral reserves, safeguarding Earth from stray celestial objects, the requirements for alternative propulsion systems and the necessity to extend our knowledge of the cosmos.

The 'why' is considered in the second part, pulling in broader philosophical, anthropological and epistemological perspectives, which provides a refreshing balance to the earlier, more technical, argument of the first section.

"Making history is not a spectator sport. It's your turn at the plate," Zubrin urges in his final sentence of *The Case for Space*. In his well-constructed, two-part visionary narrative the author makes a compelling case for us to establish humanity as a multi-planetary spacefaring species.

If you have even a passing interest in where the space industry is headed, and would like to play your part, then this book is a must-read.

★★★★½

***Niamh Shaw** is an engineer, lecturer and science communicator*

Elizabeth Pearson rounds up the latest astronomical accessories

GEAR

1 Bresser BX-5 Pro tripod

Price £163 • **Supplier** Telescope House
Tel 01342 837098 • **www.telescopehouse.com**

This lightweight tripod is great for setting up astronomical shots at night and can be reconfigured into a monopod for daytime photography. It supports 5kg of weight and has a maximum height of 185cm.

2 Laika cuddly toy dog

Price £18 • **Supplier** Science Museum
Tel 020 7942 4000 • **https://**shop.sciencemuseum.org.uk

Street dog Laika ('little barker' in Russian) helped pave the way for human spaceflight when she flew onboard Sputnik-2 in 1957. Though she didn't make it back to Earth, you can continue her legacy by giving this toy to the next generation of spacefarers.

3 Nirvana ES 4mm UWA 82º high performance eyepieces

Price £79.99 • **Supplier** Harpers Photographic
Tel 01483 756601 • **www.harpersphoto.co.uk**

Fully immerse yourself in the viewing experience with this eyepiece's 82º field of view. The short focal length provides greatly magnified views with any focal length telescope. It fits 1.25-inch drawtubes.

4 Astronomy tie

Price £9.99 • **Supplier** tiesplanet.com
Tel 01133 450304 • **https://**tiesplanet.com

Suitable for every occasion, this tie is decorated with a subtle motif featuring telescopes and planets, so you can display your love of astronomy whether in the office, at a wedding, or just out and about.

5 Svbony 1.25-inch ultraviolet, infrared, CCD camera filter

Price £13.99 • **Supplier** Northern Optics
Tel 01724 782022 • **https://**shop.northernoptics.co.uk

This filter blocks out ultraviolet and infrared light – which can fog up your images – but transmits 98 per cent of visible light allowing for shorter exposure times. It's put together using metal and high-quality glass.

6 Universal smartphone adaptor for telescopes

Price £19.99 • **Supplier** Harrison Telescopes
Tel 01322 403407 • **www.harrisontelescopes.co.uk**

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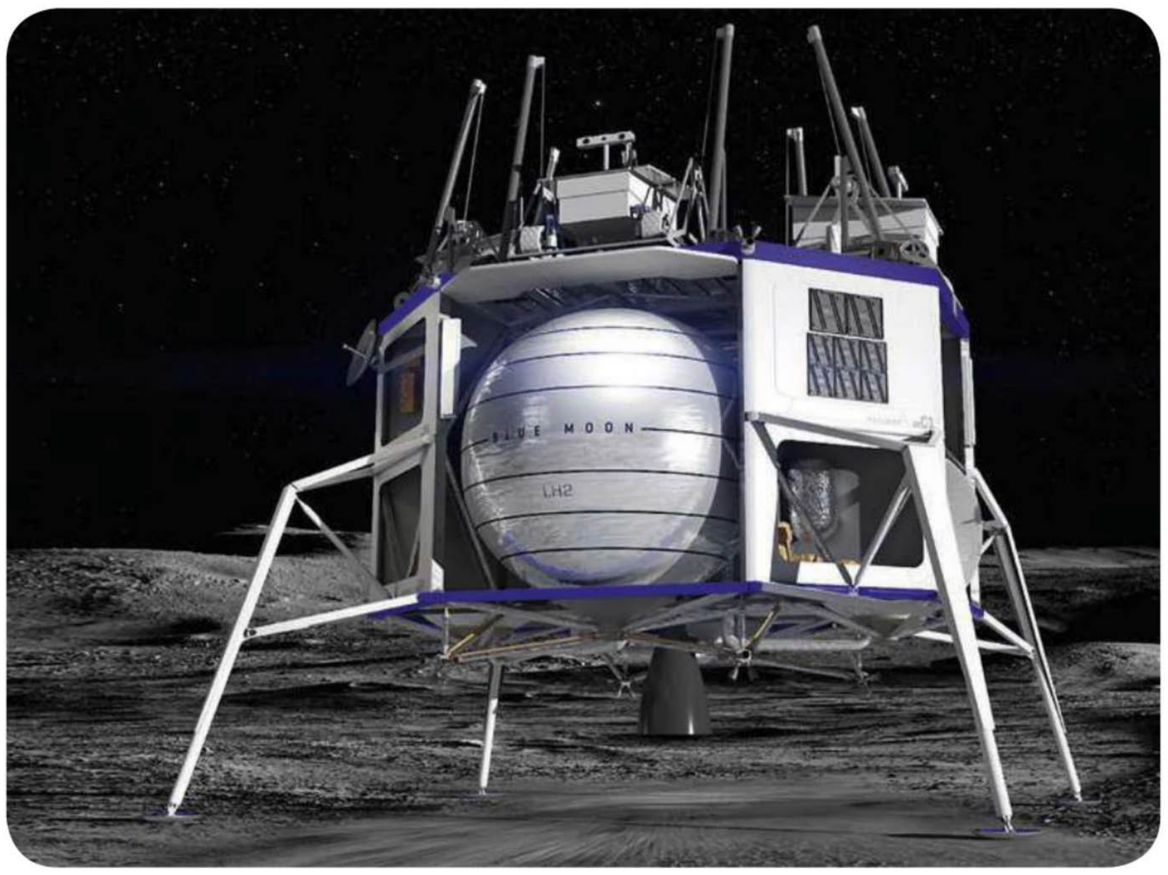
Elizabeth Pearson interviews Chris Welch

Q&A WITH A SPACE EXPLORATION EXPERT

A new lunar rush is beginning, half a century after the Apollo landings first focused humanity's attention on the Moon

Why, 50 years after Apollo, is a return to the Moon now said to be looking more realistic than ever?
It's partly a result of technology developments, partly political, and partly thanks to work carried out by people that were children at the time of the first landing, who have been trying to move the space agenda forward. Certainly, people like Jeff Bezos of Blue Origin and Elon Musk of SpaceX are motivated by that. There's been this general upwelling of interest in space and particularly in space resources, and obviously focus has returned to the Moon due to the anniversary.



▲ **Blue Origin has a concept for a lunar lander in development**

How is it politically motivated?
In the US, the big news was Vice President Mike Pence tasking NASA with putting human beings back on the Moon by 2024. The political aspect of that is that 2024 would be the final year of his second term, were President Trump to be re-elected. That enables a lot of potential publicity to be generated in 2020. Of course, the budget has to be approved before any of this could happen.

How much would it cost?
Trump has asked for a $20 billion a year allocation for the agency as a whole, but NASA has said actually it needs $1.6 billion more. There have been various estimates of what it will cost to do this by 2024, between $6-8 billion per year, which is a lot of money. Where does that money come from? There's talk about using offsets, which is basically a way of saying "we're going to take the money from elsewhere in the government expenditure".

Then, of course, the next question is where else is that money going to come from and who is going to fight for it? And then the biggest obstacle becomes the US domestic political situation. We just have to wait and watch on that one.

BLUE ORIGIN

Can the US make the deadline?
2024 is technically ambitious even if you have the money. The original plans were for an international project called the Lunar Gateway – a small space station in a lunar orbit, from which one could go down to the Moon. That was supposed to happen closer to 2028-2030.

What's happened now is that the Lunar Gateway has been descoped a little and initially prioritised for the US, so by 2024 it will only be two American modules. Any international partners will have to wait until 2028 to actually send their sections.

Everything also depends on the progress of NASA's Space Launch System project, which is currently under development – and that programme has slipped a bit. It has been allocated more money so it can be completed by 2024, but a lot of things have to go right for them to meet that goal.

Is the US in a new space race with China?
China certainly has its eyes on the Moon. I don't think either side has claimed it as a competition, but given contemporary geopolitics that is clearly an aspect. One of the big issues is that America and China cannot work directly together even if they want to – it's illegal under US law. But that doesn't stop other forms of collaboration. ESA has been talking to China. So we have these two poles at the moment – America and China. Then you have the international community and an emerging private sector, which allows more people to be involved.

Why are we returning to the Moon?
Science and money. When you look at the number of science hours on the Moon, there's very little been done so far. We've landed in a few places. We've brought back some rocks and lunar samples. Then there's the question of developing space commerce. Launch costs are reducing and as more space businesses make money in low-Earth orbit, more people start to close the imagination gap and think, 'Maybe it's possible to make money'. Maybe it is possible for scientists who want to do experiments to do them with a private provider. Maybe it doesn't all have to be done by governments.

Chris Welch is a professor of astronautics and space engineering at the International Space University, and a member of the Moon Village Association

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Catch the Aquariids and get a ringside seat as bright Saturn puts on a show all month

When to use this chart

1 July at 24:00 AEDT (13.00 UT)
15 July at 23:00 AEDT (12.00 UT)
31 July at 22:00 AEDT (11.00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

JULY HIGHLIGHTS

With Saturn at opposition, it reaches maximum brightness and presents its largest image for the year. Being up all night, there's plenty of time to enjoy its superb ring system, which has reached a maximum width of roughly 42 arcseconds for 2019. The Southern Delta Aquariids (12 July–23 August) are one of the stronger, consistent southern showers, peaking around 30 July – conveniently just before new Moon. Look for their mostly faint, blue/white members in the morning hours.

STARS AND CONSTELLATIONS

The brightest star in Scorpius is Antares (Alpha (α) Scorpii). Brilliant red, Antares is referred to as the 'heart of the scorpion' given its position within this arachnid-shaped asterism. Its two flanking naked-eye stars, Sigma (σ) and Tau (τ) Scorpii, also support this idea, both sharing the ancient name Alniyat, from an Arabic term meaning 'the arteries'. These two hot, blue stars stand in contrast to the cooler redness of Antares, a difference easily seen with binoculars.

THE PLANETS

Mars and Mercury are visible low in the western twilight. They travel together for the first half of July, before Mercury drops into the solar glare. Looking north, Jupiter continues its prominence, transiting the meridian around 21:30 mid-month. Saturn follows, being due north around midnight mid-July. These gas giants are soon joined by their outer Solar System companions. Neptune is best seen in the morning, transiting around 04:00. Uranus achieves a good altitude by dawn.

DEEP-SKY OBJECTS

This month, we take a brief dip in the Milky Way with a visit to Ophiuchus. On the southern (top) end of the Coffin asterism lies the naked-eye star, Eta (η) Ophiuchi. Move 2.5° to the southeast and discover the bright star cluster NGC6333 or M9 (RA 17h 19.2m, dec. -18° 31'). At mag. +7.7 this globular has a bright, obvious core (2 arcminutes), with a star-rich halo extending out to around 5 arcminutes.

West of M9 the star numbers are notably reduced, leading to an obvious 8 arcminute-wide circular black patch: the dark nebula Barnard 64. Separated by only 0.5°, both fit in the same low-power field (50x). M9 is the brightest member of a trio of globular clusters, the others a little over 1° away. To the northeast lies NGC 6356 (mag. +8.2) and southeast is NGC 6342 (mag. +9.5).

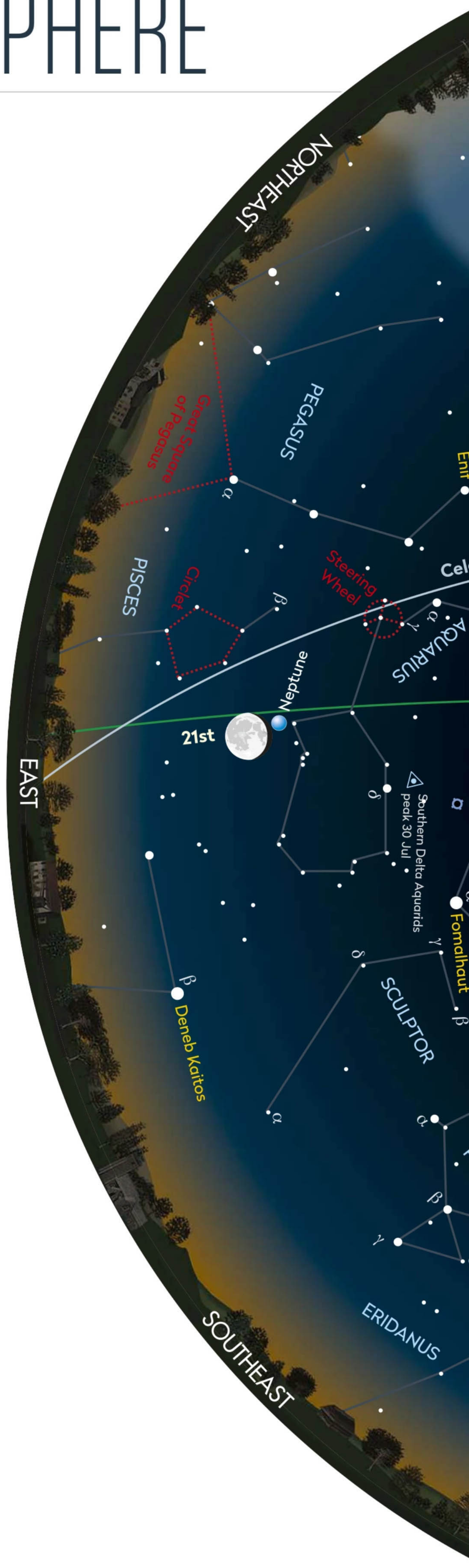
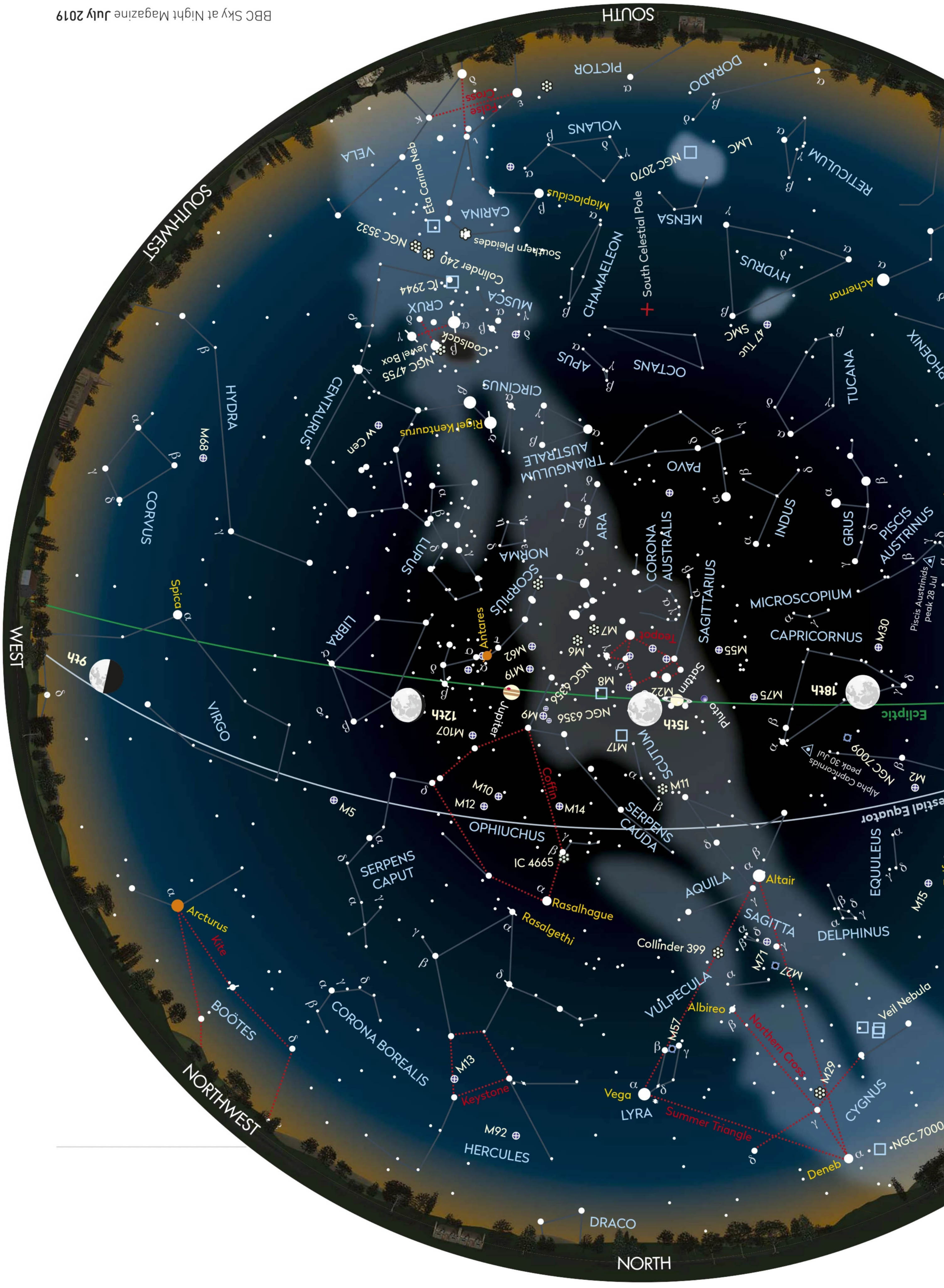


Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET
- STAR BRIGHTNESS:
  - MAG. 0 & BRIGHTER
  - MAG. +1
  - MAG. +2
  - MAG. +3
  - MAG. +4 & FAINTER

CHART: PETE LAWRENCE


SOUTH
SOUTHWEST
SOUTHEAST
WEST
NORTHWEST
NORTH
PICTOR
DORADO
VOLANS
LMC
NGC 2070
RETICULUM
VELA
False Cross
Eta Carina Neb
CARINA
Miaplacidus
MENSA
South Celestial Pole
CHAMAELEON
NGC 3532
Southern Pleiades
Collinder 240
IC 2944
MUSCA
CRUX
Coalsack
Jewel Box
NGC 4755
HYDRA
M68
CENTAURUS
ω Cen
Rigel Kentaurus
CIRCINUS
HYDRUS
Achernar
SMC
47 Tuc
APUS
OCTANS
TUCANA
TRIANGULUM AUSTRALE
PAVO
INDUS
CORVUS
Spica
LUPUS
NORMA
ARA
CORONA AUSTRÁLIS
GRUS
PISCIS AUSTRINUS
Piscis Austrinids
peak 28 Jul
MICROSCOPIUM
CAPRICORNUS
M30
M55
M75
Teapot
M7
M6
M8
M22
Saturn
Pluto
Jupiter
M62
M19
M9
NGC 6356
M17
SCULPTUM
Ecliptic
Alpha Capricornids
peak 30 Jul
NGC 7009
M2
Celestial Equator
9th
12th
15th
18th
M107
M10
M12
M5
Coffin
M14
OPHIUCHUS
SERPENS CAUDA
M11
IC 4665
SERPENS CAPUT
Arcturus
Kite
Rasalhague
Rasalgethi
AQUILA
Altair
EQUULEUS
M15
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M27
BOÖTES
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M13
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Albireo
M57
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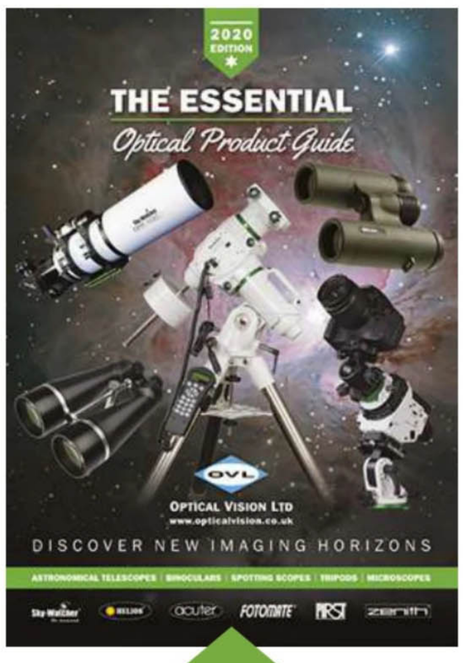

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